US009197853B2

(12) **United States Patent**
Shi et al.

(10) **Patent No.: US 9,197,853 B2**
(45) **Date of Patent: Nov. 24, 2015**

(54) **SWITCHING BETWEEN VIEWS USING NATURAL GESTURES**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 136 days.

(21) Appl. No.: **14/019,915**

(22) Filed: **Sep. 6, 2013**

(65) **Prior Publication Data**

US 2014/0340465 A1 Nov. 20, 2014

Related U.S. Application Data

(60) Provisional application No. 61/825,482, filed on May 20, 2013.

(51) **Int. Cl.**

H04N 7/14	(2006.01)
H04N 7/15	(2006.01)
G06F 3/00	(2006.01)
H04N 21/414	(2011.01)
H04N 21/4788	(2011.01)

(52) **U.S. Cl.**

CPC .. ***H04N 7/15*** (2013.01); ***G06F 3/00*** (2013.01); *H04N 21/41407* (2013.01); *H04N 21/4788* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,999,208	A	12/1999	McNerney et al.	
6,970,181	B1	11/2005	Fadel	
7,590,941	B2	9/2009	Wee et al.	
7,616,840	B2	11/2009	Erol et al.	
8,223,186	B2	7/2012	Derocher et al.	
8,330,793	B2	12/2012	Robinson et al.	
2009/0046075	A1 *	2/2009	Kim et al.	345/173
2010/0077431	A1	3/2010	Neufeld et al.	
2011/0249073	A1 *	10/2011	Cranfill et al.	348/14.02
2012/0229591	A1 *	9/2012	Lee	348/14.08
2013/0083151	A1 *	4/2013	Kim et al.	348/14.07
2013/0147906	A1 *	6/2013	Weiser et al.	348/14.09
2014/0215356	A1 *	7/2014	Brander et al.	715/753

OTHER PUBLICATIONS

Cisco, WebEx Meetings "Better Meetings from beginning to end", http://www.webex.com/products/web-conferencing.html, Jul. 19, 2013, 3 pages.

(Continued)

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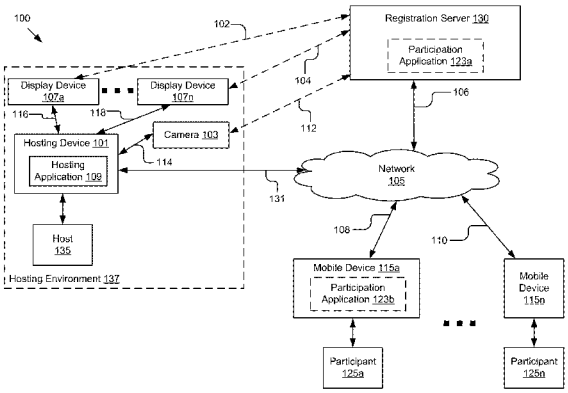
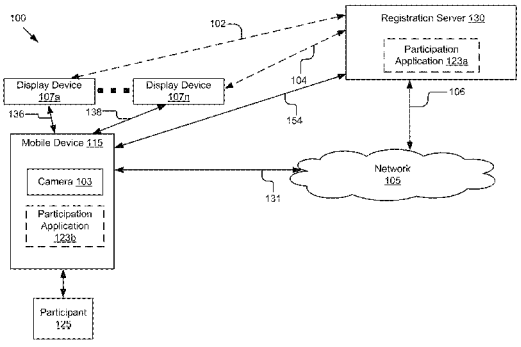
(57) **ABSTRACT**

The disclosure includes a system and method for switching between video views and data views. The system includes a controller, a view presentation module, a screen detection module and a view switching module. The controller receives data indicating a participant joined a multi-user communication session. The view presentation module presents a video stream on a mobile device associated with the participant. The screen detection module determines an occurrence of a detection trigger event. The controller receives a video frame image responsive to the occurrence of the detection trigger event. The screen detection module detects a data screen in the video frame image. The view switching module switches a view on the mobile device from video view to data view responsive to a natural gesture performed by the participant. The view presentation module presents a data stream associated with the data screen on the mobile device.

20 Claims, 13 Drawing Sheets





(56) **References Cited**

OTHER PUBLICATIONS

Vidyo Mobile, "VidyoMobile Supported Devices," http://www.vidyo.com/products/vidyomobile/, Jul. 19, 2013, 2 pages.

Class X, Stanford University, "ClassX Interactive Streaming," http://classx.stanford.edu/ClassX/stanford_front_pages/mobile/, dated 2011, 1 page.

Google Maps, https://maps.google.com, Jul. 19, 2013, 1 page.

Ambulant, Open SMIL Player, News Demo, http://www.ambulantplayer.org/Demo-News-PlugIn.shtml, dated Jun. 1, 2010, 1 page.

Bajura, et al., Merging Virtual Objects with the Real World—Seeing Ultrasound Imagery within the Patient, dated Jul. 2, 1992, 8 pages, Department of Computer Science, University of North Carolina.

Prince et al., 3D Live: Real Time Captured Content for Mixed Reality, dated 2002, 8 pages, IEEE—Computer Society.

Hess, An Open-Source SIFT Library, dated Oct. 25-29, 2010, 4 pages, ACM, Firenza Italy.

Cockburn, Andy, Amy Karlson, and Benjamin B. Bederson. "A review of overview+ detail, zooming, and focus+ context interfaces." ACM Computing Surveys (CSUR) 41.1 (2008): 2.

* cited by examiner

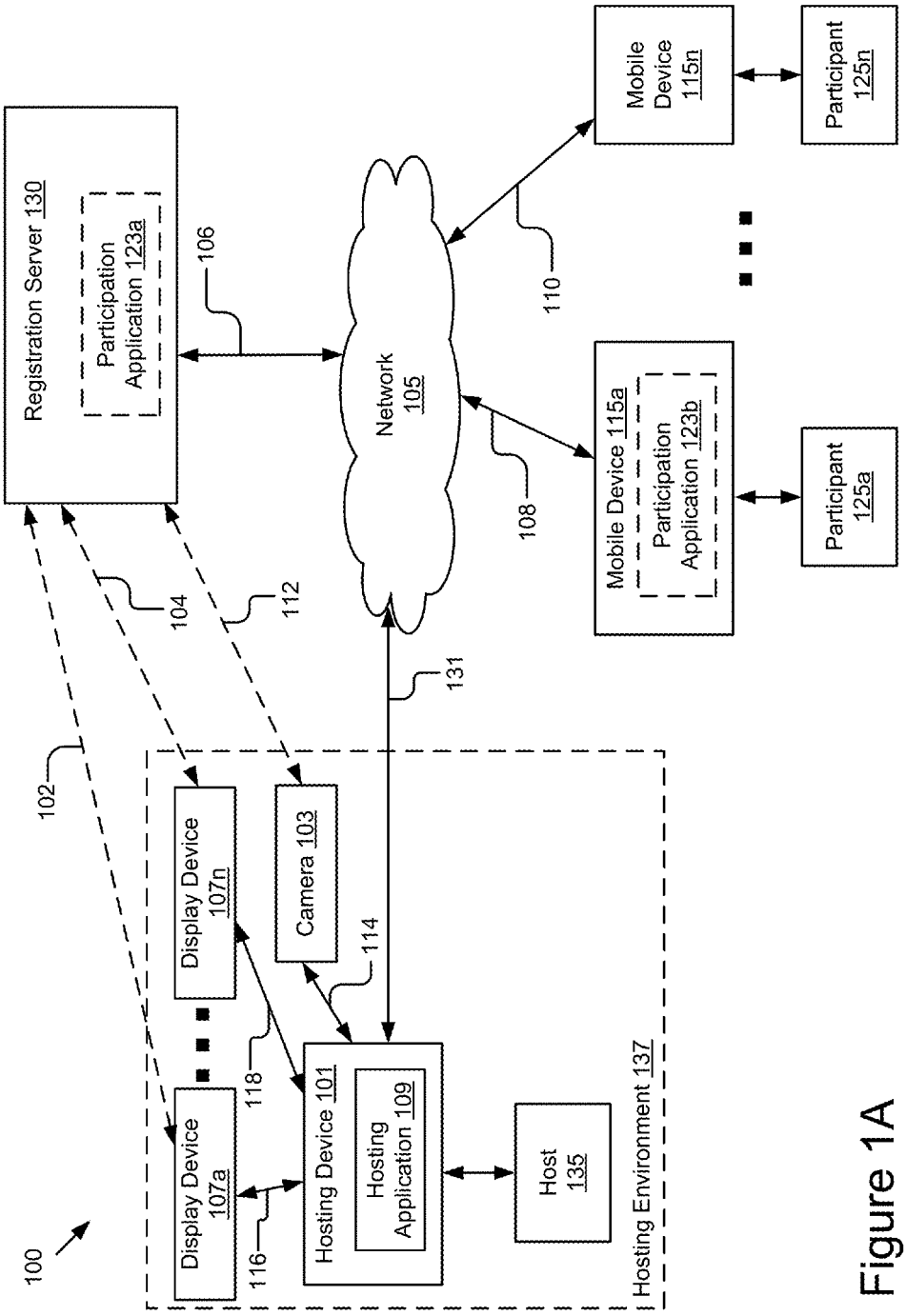

100
Registration Server 130
Participation Application 123a
Network 105
Mobile Device 115n
Participant 125n
Mobile Device 115a
Participation Application 123b
Participant 125a
Hosting Environment 137
Display Device 107a
Display Device 107n
Camera 103
Hosting Device 101
Hosting Application 109
Host 135
102
104
106
108
110
112
114
116
118
131

Figure 1A

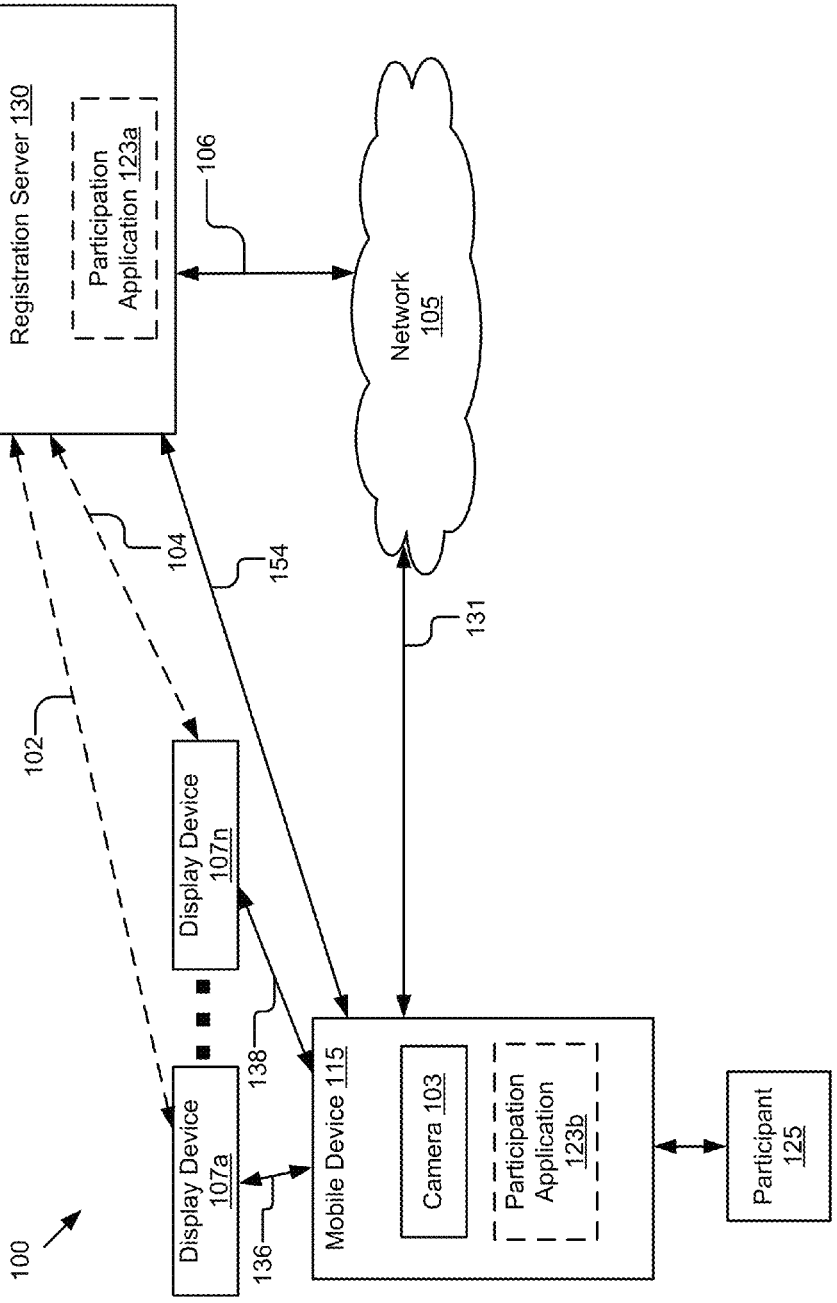

Registration Server 130
Participation Application 123a
106
Network 105
104
154
131
102
Display Device 107n
138
Mobile Device 115
Camera 103
Participation Application 123b
Participant 125
Display Device 107a
136
100

Figure 1B

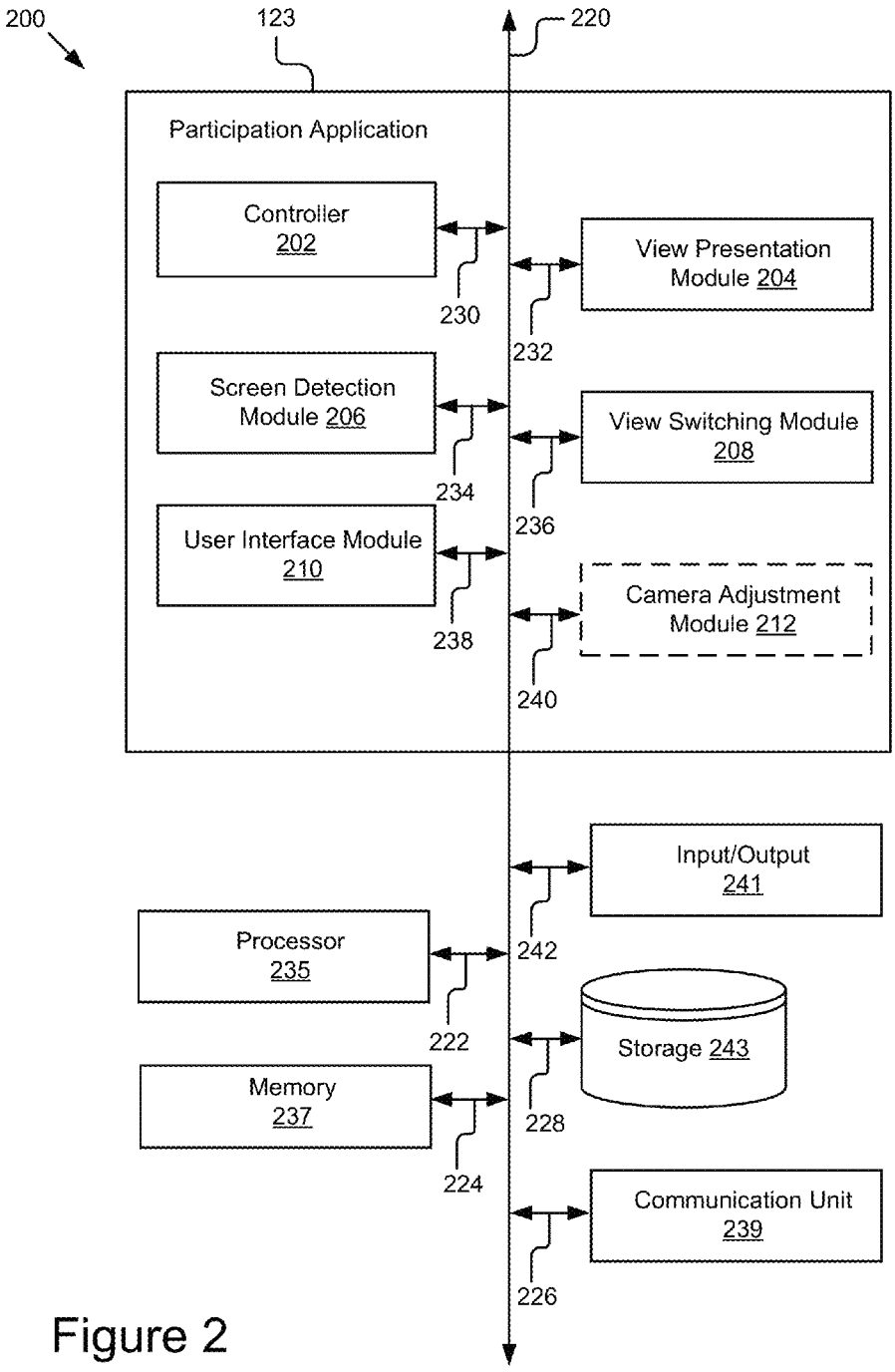

200
123
220
Participation Application
Controller 202
View Presentation Module 204
230
232
Screen Detection Module 206
View Switching Module 208
234
236
User Interface Module 210
Camera Adjustment Module 212
238
240
Input/Output 241
Processor 235
242
222
Storage 243
Memory 237
228
224
Communication Unit 239
226

Figure 2

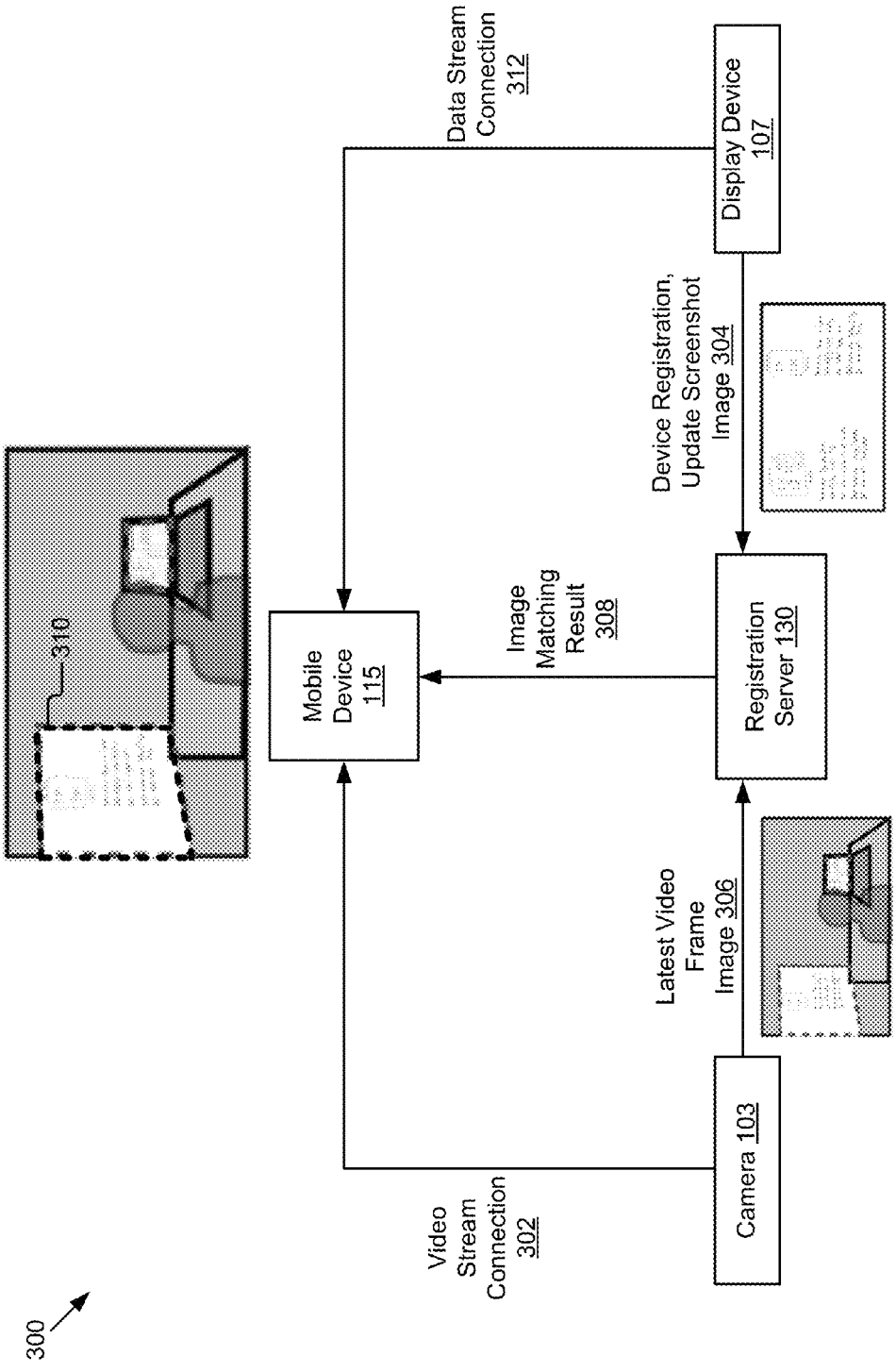

300
Video Stream Connection 302
Camera 103
Latest Video Frame Image 306
Registration Server 130
Image Matching Result 308
Mobile Device 115
Device Registration, Update Screenshot Image 304
Display Device 107
Data Stream Connection 312
310

Figure 3A

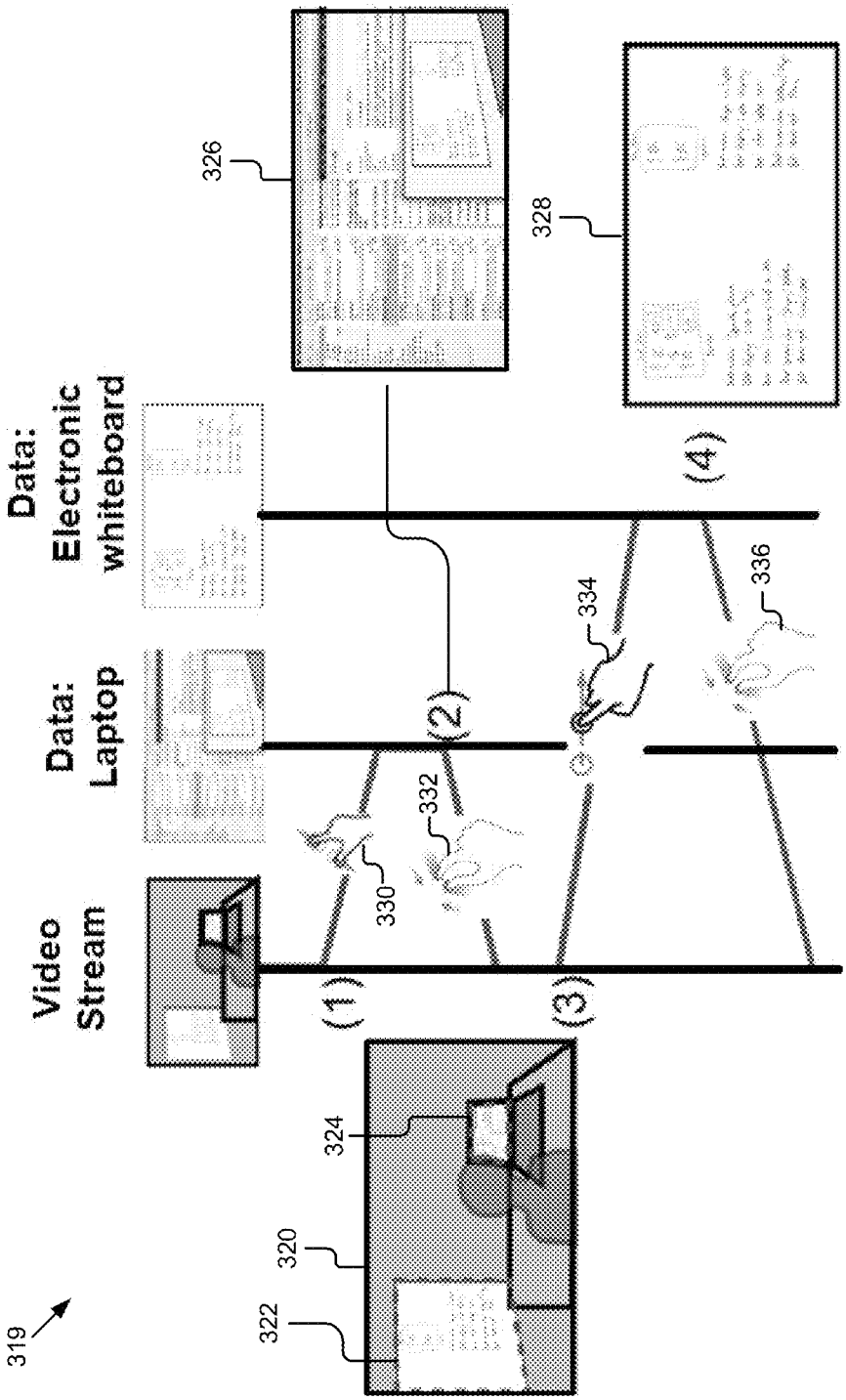

319
322
320
324
Video Stream
Data: Laptop
Data: Electronic whiteboard
(1)
(2)
(3)
(4)
326
328
330
332
334
336

Figure 3B

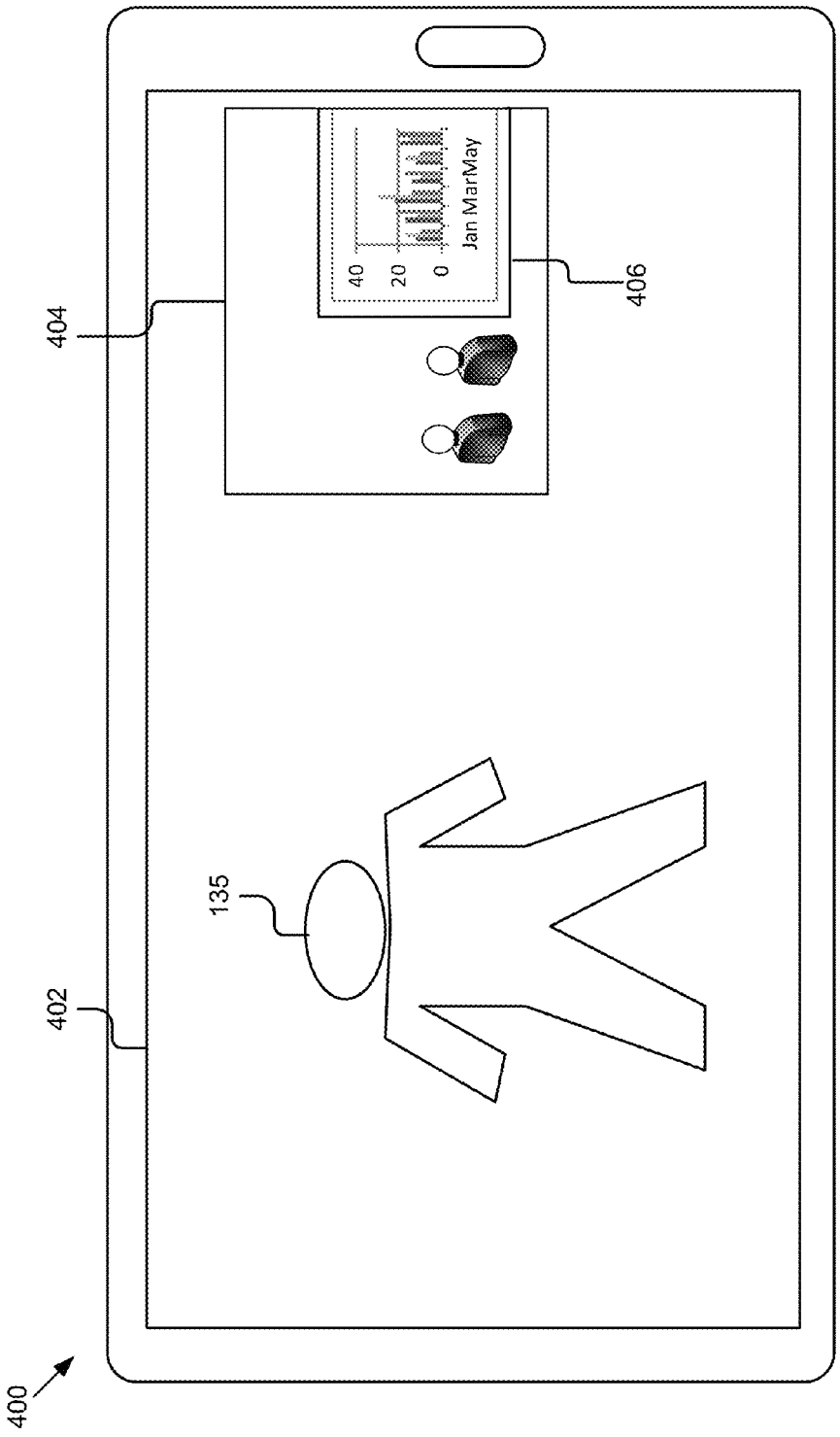


Figure 4A

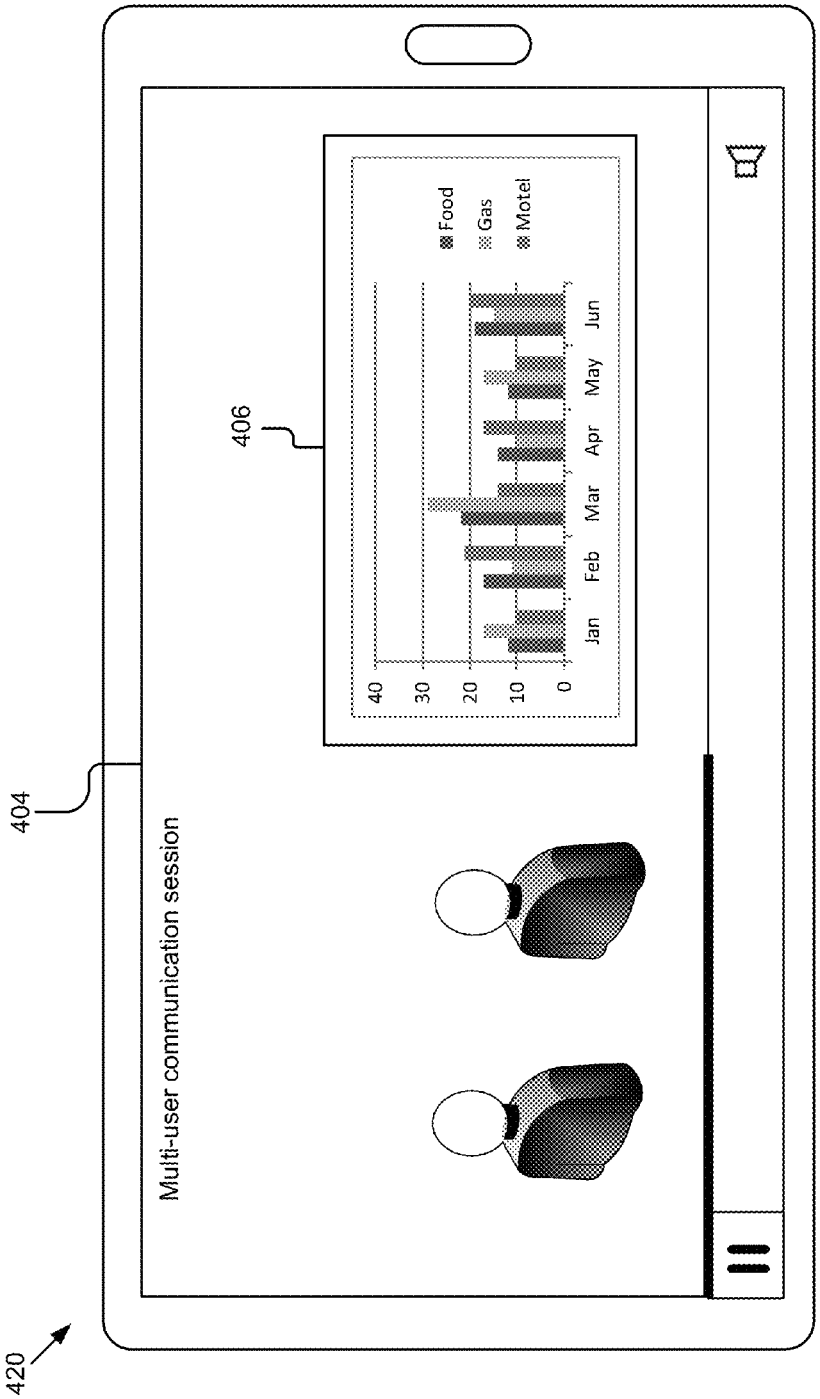

420
404
Multi-user communication session
406
Food
Gas
Motel
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun

Figure 4B

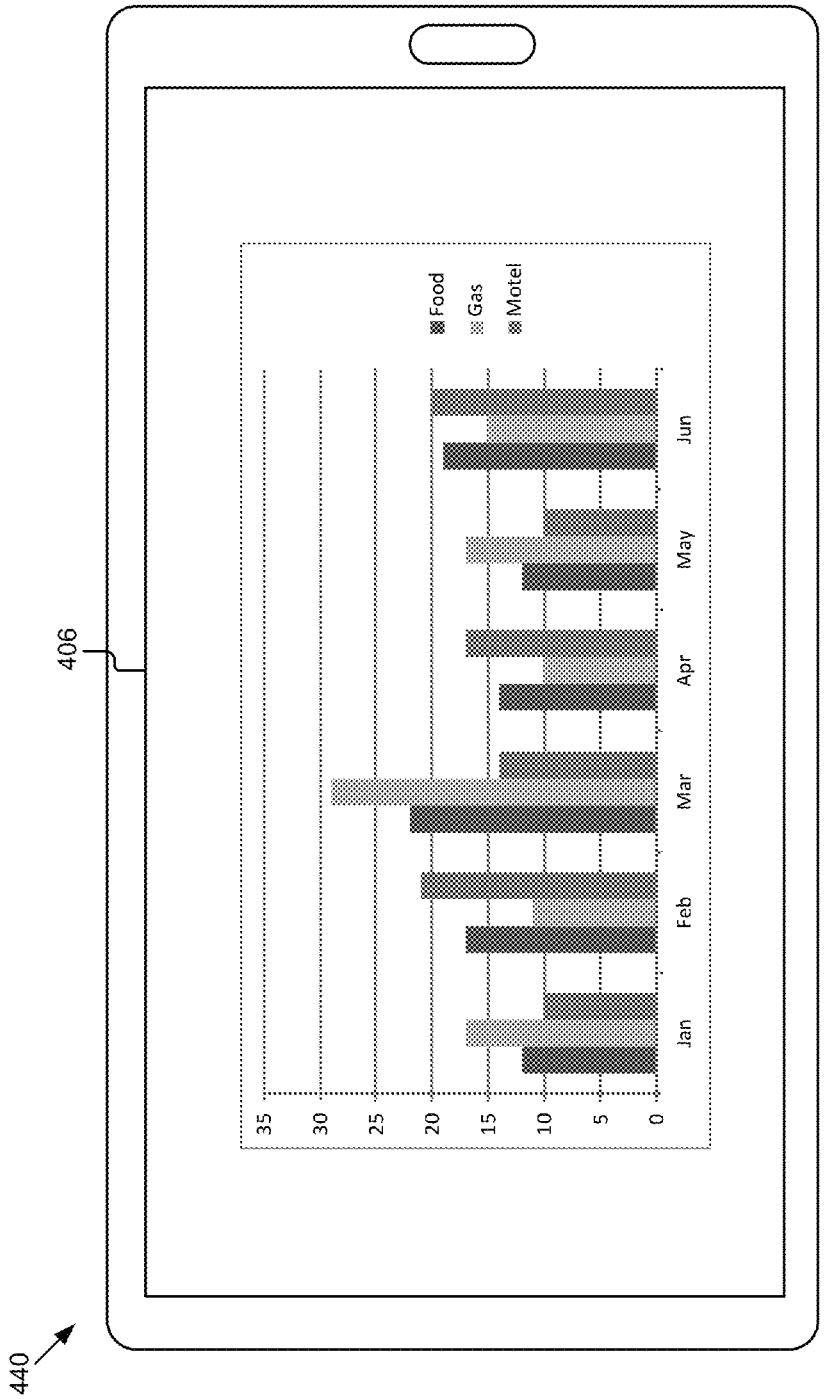

406
440
Food
Gas
Motel
35
30
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun

Figure 4C

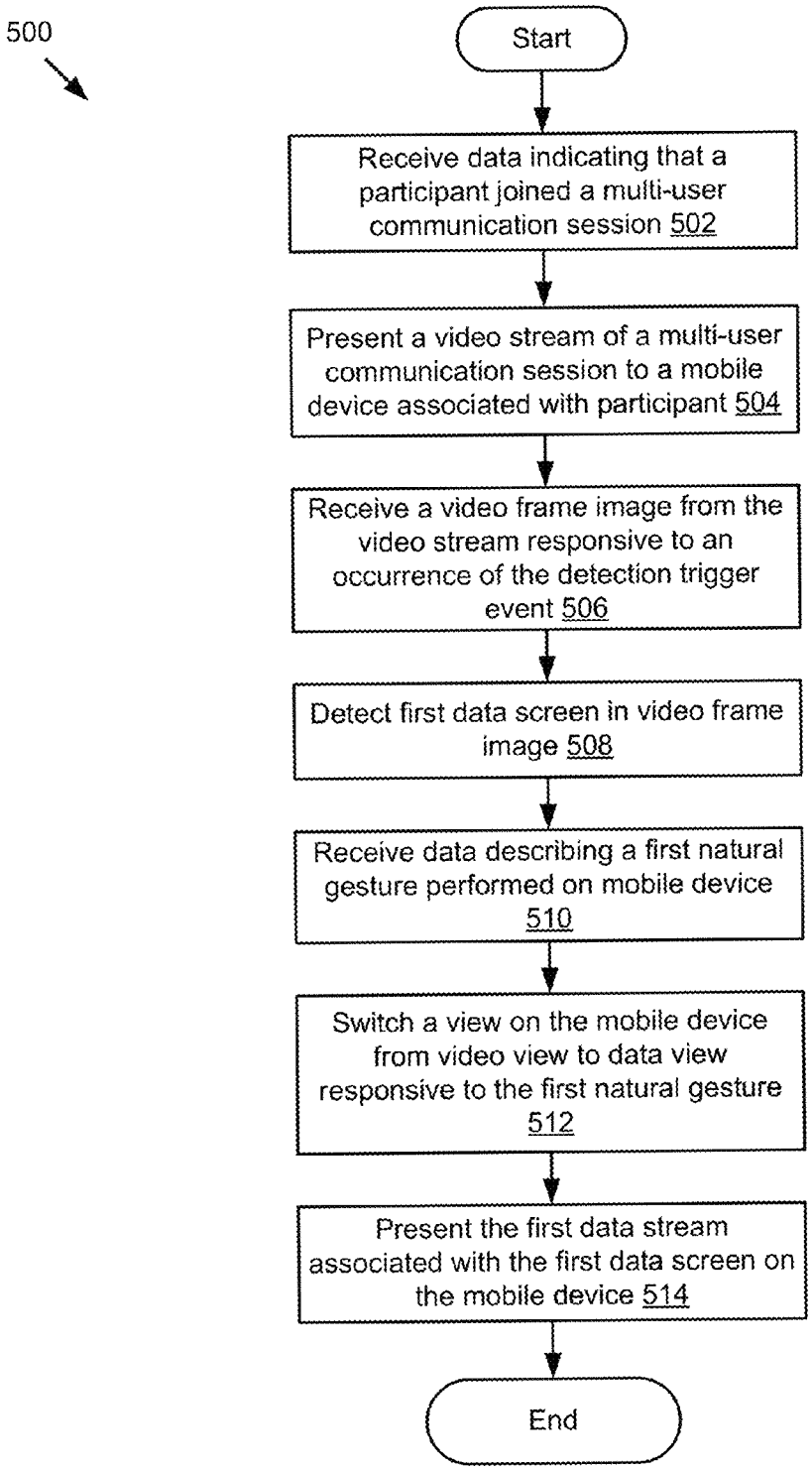

500
Start
Receive data indicating that a participant joined a multi-user communication session 502
Present a video stream of a multi-user communication session to a mobile device associated with participant 504
Receive a video frame image from the video stream responsive to an occurrence of the detection trigger event 506
Detect first data screen in video frame image 508
Receive data describing a first natural gesture performed on mobile device 510
Switch a view on the mobile device from video view to data view responsive to the first natural gesture 512
Present the first data stream associated with the first data screen on the mobile device 514
End

Figure 5

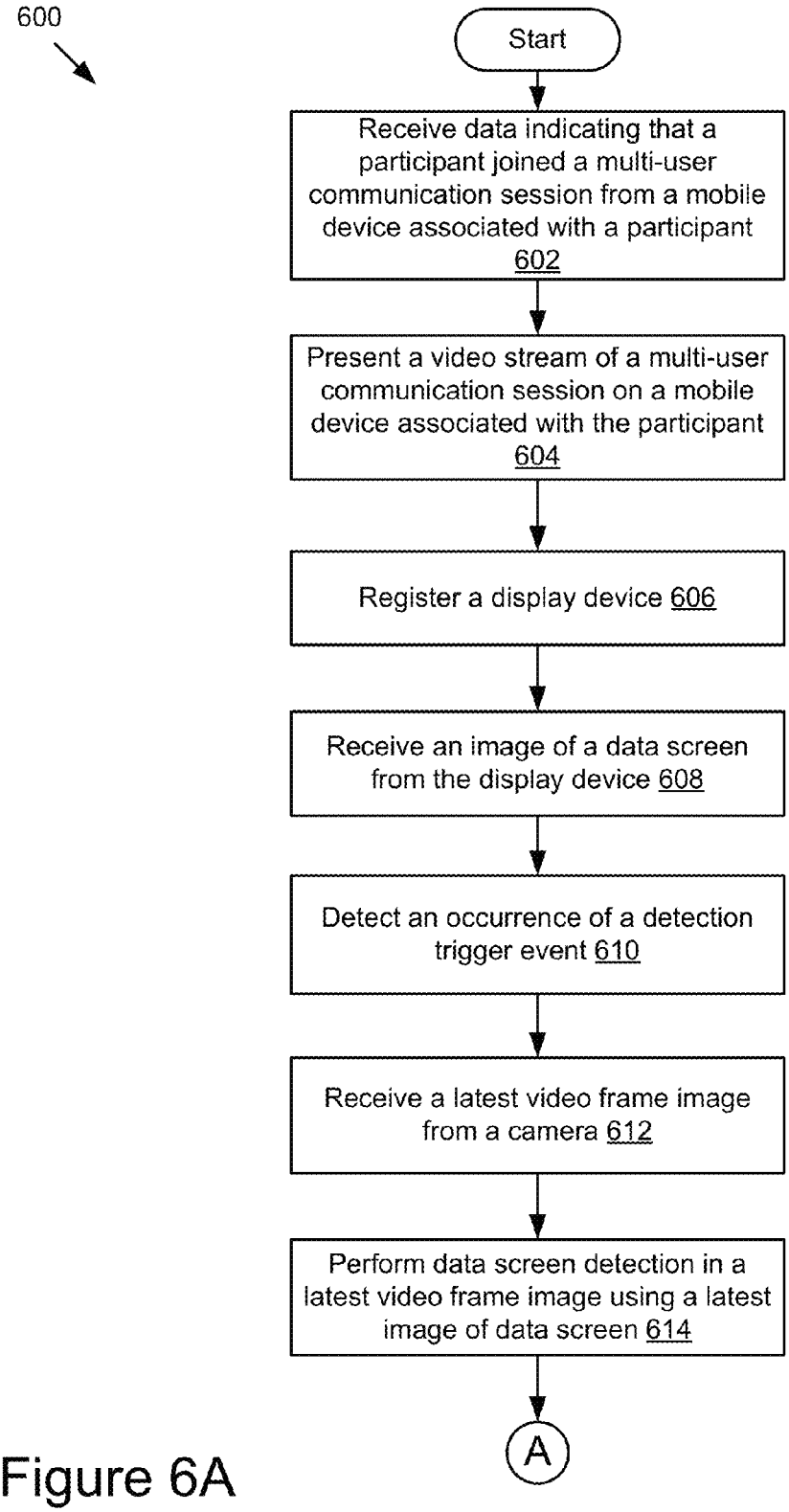

600
Start
Receive data indicating that a participant joined a multi-user communication session from a mobile device associated with a participant 602
Present a video stream of a multi-user communication session on a mobile device associated with the participant 604
Register a display device 606
Receive an image of a data screen from the display device 608
Detect an occurrence of a detection trigger event 610
Receive a latest video frame image from a camera 612
Perform data screen detection in a latest video frame image using a latest image of data screen 614
A

Figure 6A

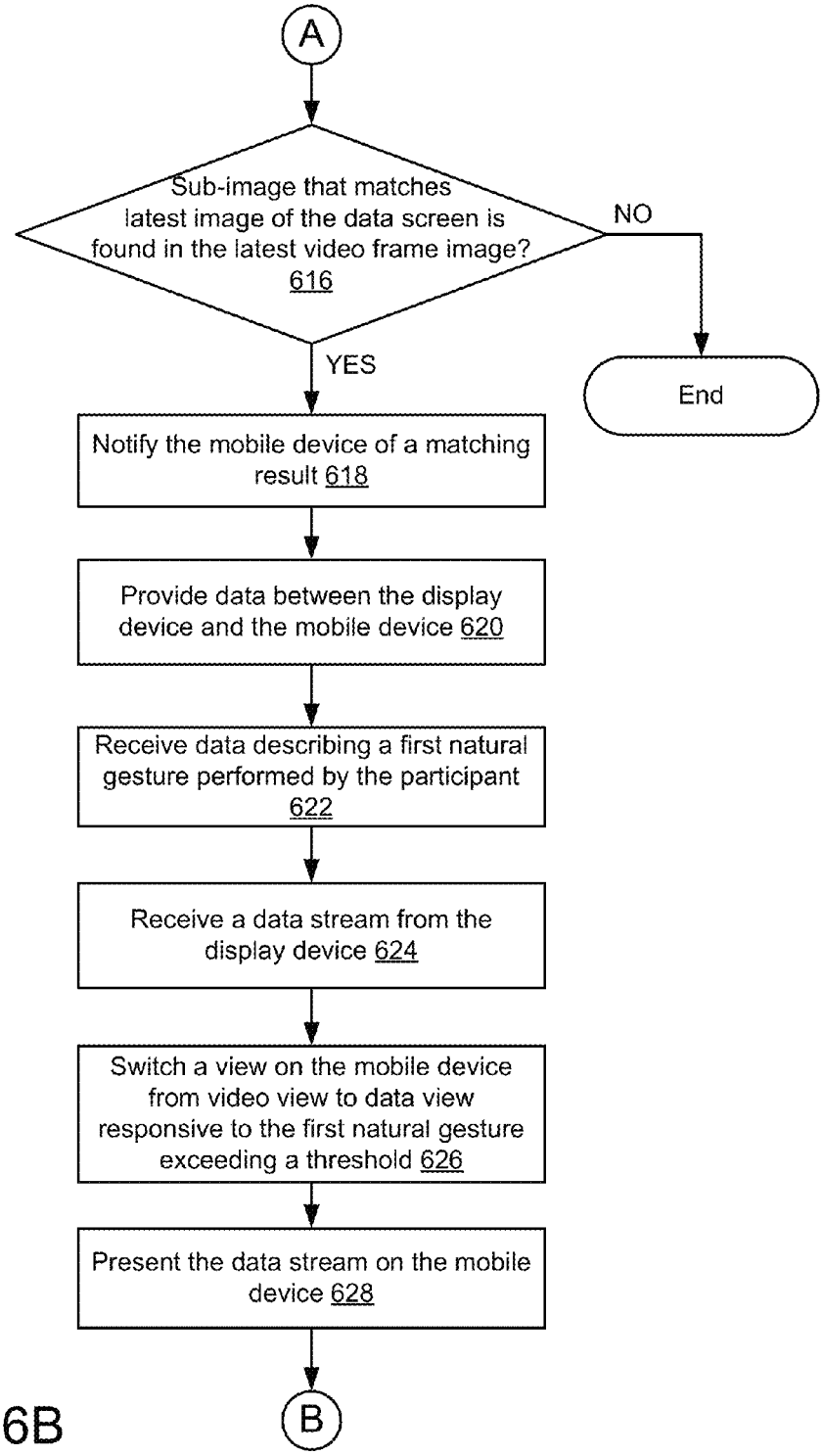

A
Sub-image that matches latest image of the data screen is found in the latest video frame image? 616
NO
End
YES
Notify the mobile device of a matching result 618
Provide data between the display device and the mobile device 620
Receive data describing a first natural gesture performed by the participant 622
Receive a data stream from the display device 624
Switch a view on the mobile device from video view to data view responsive to the first natural gesture exceeding a threshold 626
Present the data stream on the mobile device 628
B

Figure 6B

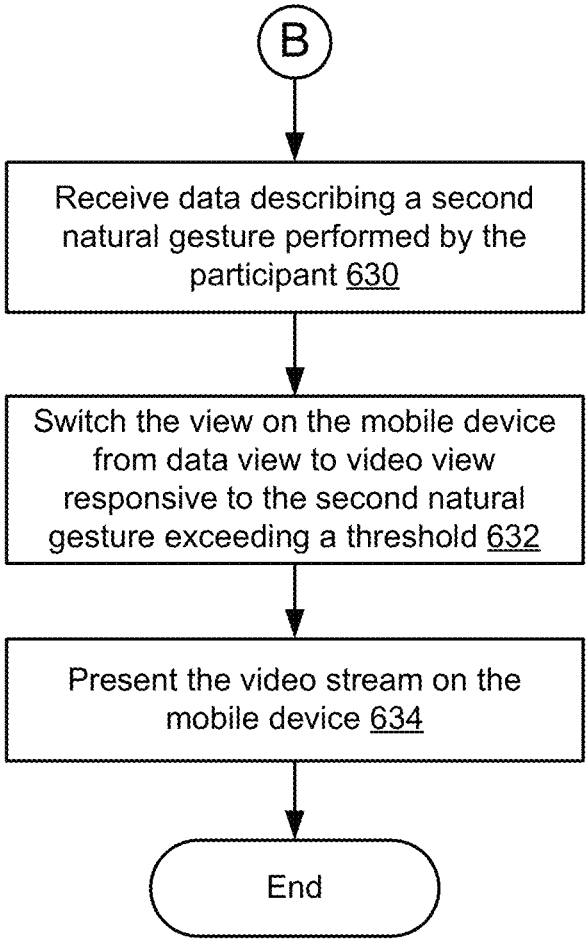

B
Receive data describing a second natural gesture performed by the participant 630
Switch the view on the mobile device from data view to video view responsive to the second natural gesture exceeding a threshold 632
Present the video stream on the mobile device 634
End

Figure 6C

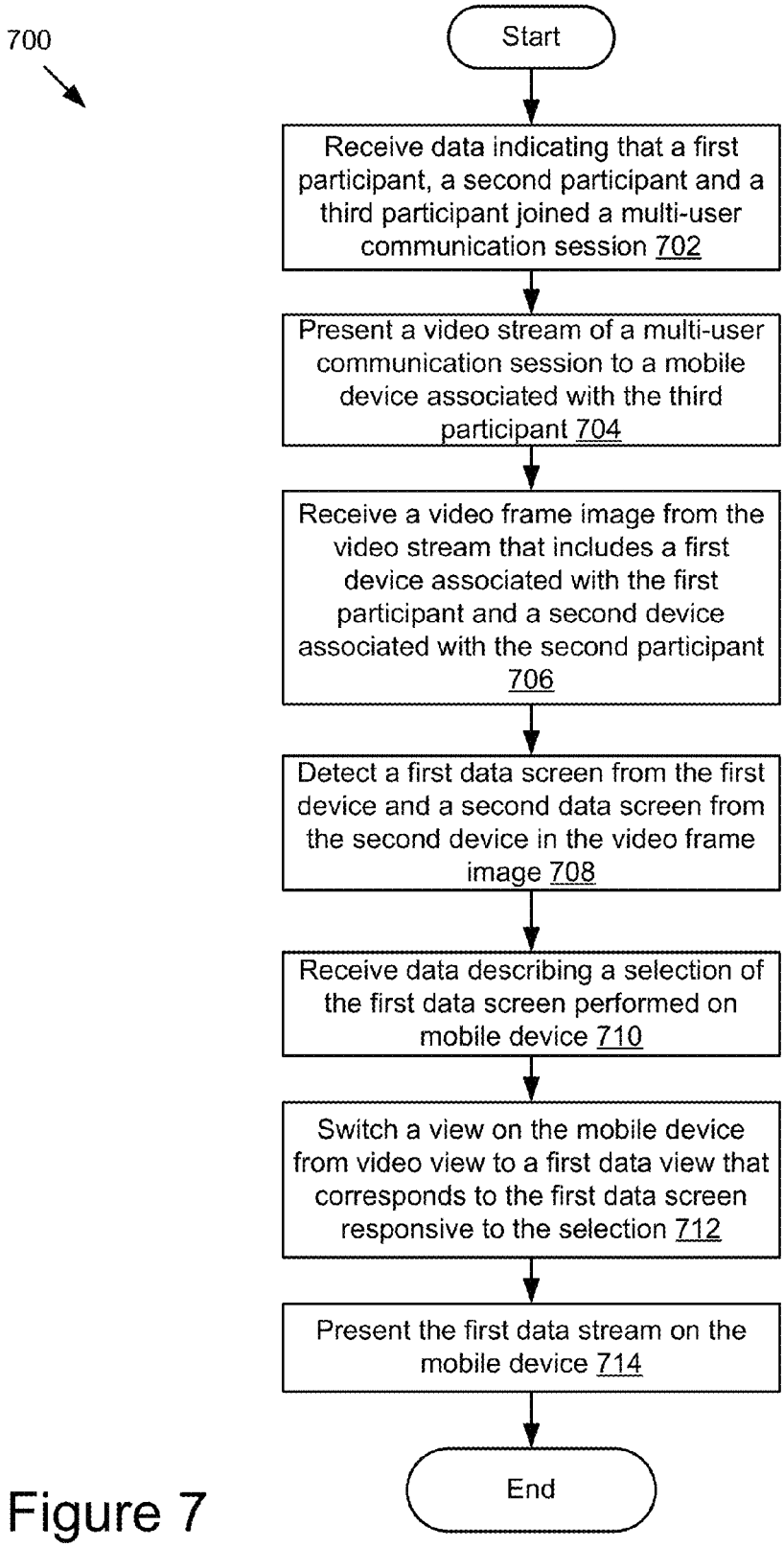

700
Start
Receive data indicating that a first participant, a second participant and a third participant joined a multi-user communication session 702
Present a video stream of a multi-user communication session to a mobile device associated with the third participant 704
Receive a video frame image from the video stream that includes a first device associated with the first participant and a second device associated with the second participant 706
Detect a first data screen from the first device and a second data screen from the second device in the video frame image 708
Receive data describing a selection of the first data screen performed on mobile device 710
Switch a view on the mobile device from video view to a first data view that corresponds to the first data screen responsive to the selection 712
Present the first data stream on the mobile device 714
End

Figure 7

SWITCHING BETWEEN VIEWS USING NATURAL GESTURES

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority under 35 USC §119(e) to U.S. Application No. 61/825,482, entitled "Method of Switching between Views in Mobile Videoconferencing Using Gestures" filed May 20, 2013, the entirety of which is herein incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The specification relates to a system and method for switching between video views and data views. In particular, the specification relates to a system and method for switching between video views and data views using natural gestures in mobile videoconferencing.

2. Description of the Background Art

Existing videoconferencing systems collect and transmit data streams along with video and audio streams in a videoconference session. This is because in most business meetings, the users expect to not only see each other, but also to exchange data information, such as documents, presentation slides, handwritten comments, etc. These data streams are usually directly captured from computer screens, separately encoded with special coding tools, and displayed side-by-side with the video streams on a remote site.

The explosion of mobile devices drives more and more videoconferencing service providers to develop mobile applications such as smart phone and tablet applications. These mobile applications make it much easier for the users to access the videoconferencing service from anywhere using mobile devices.

However, it becomes a problem to display both a video view and a data view on the mobile device simultaneously. Due to the limited screen size of the mobile device, it is not possible to display both the video view and the data view at full resolution side-by-side. Currently, the commonly used method is to use a user interface that displays one view at the full screen scale while showing only the thumbnail for the other view. The user interface combines and displays the video view and the data view together. Such a user interface fails to provide a unified experience by separating the user interface into multiple view modes, and may cause confusion when there is more than one data stream.

SUMMARY OF THE INVENTION

The disclosure includes a system and method for switching between video views and data views on a mobile device. In one embodiment, the system includes a controller, a view presentation module, a screen detection module and a view switching module. The controller receives data indicating a participant joins a multi-user communication session. The view presentation module presents a video stream of the multi-user communication session on a mobile device associated with the participant. The screen detection module determines an occurrence of a detection trigger event. The controller receives a video frame image from the video stream responsive to the occurrence of the detection trigger event. The screen detection module detects a first data screen in the video frame image. The controller receives data describing a first natural gesture performed on the mobile device. The view switching module switches a view on the mobile device from video view to data view responsive to the first natural gesture. The view presentation module presents a first data stream associated with the first data screen on the mobile device.

In another embodiment, a computer-implemented method with the following steps is performed. The method receives data indicating that a first participant, a second participant and a third participant joined a multi-user communication session. The method presents a video stream of a multi-user communication session to a mobile device associated with the third participant. The method receives a video frame image from the first video stream that includes a first device associated with the first participant and a second device associated with the second participant. The method detects a first data screen from the first device and a second data screen from the second device in the video frame image. The method receives data describing a selection of the first data screen performed on the mobile device. The method switches a view on the mobile device from video view to a first data view that corresponds to the first data screen responsive to the selection. The method presents the first data stream on the mobile device.

Other aspects include corresponding methods, systems, apparatuses, and computer program products for these and other innovative aspects.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is illustrated by way of example, and not by way of limitation in the figures of the accompanying drawings in which like reference numerals are used to refer to similar elements.

FIG. **1**A is a high-level block diagram illustrating one embodiment of a system for switching between video views and data views.

FIG. **1**B is a high-level block diagram illustrating another embodiment of a system for switching between video views and data views.

FIG. **2** is a block diagram illustrating one embodiment of a participation application.

FIG. **3**A is a graphic representation illustrating one embodiment of a process for performing data screen detection.

FIG. **3**B is a graphic representation illustrating one embodiment for switching between video views and data views on a mobile device using natural gestures.

FIG. **4**A is a graphic representation of one embodiment of a graphic user interface illustrating a video view mode on a mobile device.

FIG. **4**B is a graphic representation of one embodiment of a graphic user interface illustrating a data view mode on a mobile device.

FIG. **4**C is a graphic representation of one embodiment of a graphic user interface illustrating an embedded data view mode on a mobile device.

FIG. **5** is a flow diagram illustrating one embodiment of a method for switching between video views and data views using natural gestures in a multi-user communication session.

FIGS. **6**A-**6**C are flow diagrams illustrating another embodiment of a method for switching between video views and data views using natural gestures in a multi-user communication session.

FIG. **7** is a flow diagram illustrating one embodiment of a method for switching between a video view and one of two different data views using a selection in a multi-user communication session.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The system described in the disclosure is particularly advantageous in numerous respects. First, the system allows a participant to use natural gestures such as pinch gestures to switch between video views and data views, and is capable of providing consistent and seamless user experience in multi-user communication sessions including mobile videoconferencing sessions.

Second, the system is capable of automatically detecting data screens in video frame images. A participant sees a data screen in a video view before switching to a data view showing the data screen in full resolution, which allows the participant to understand the relationship between a data stream of the data screen and the video content in the video view and therefore avoids confusion when more than one data stream is present. For example, if a speaker in a conference room moves frequently between two or more data screens such as a projector screen and a whiteboard screen, the system can eliminate a remote viewer's confusion between the projector screen and the whiteboard screen when the remote viewer frequently switches between the video view and the projection screen data view or between the video view and the whiteboard screen data view.

Third, the system supports embedded data streams and is capable of providing embedded data streams to users. For example, the system can present a data stream of a current meeting in a data view mode, where the data stream of the current meeting is a video clip describing a meeting. The video clip is embedded with slides and whiteboard stoke information presented in the previous meeting. The system can switch from the data view mode to the embedded data view mode to present the embedded slides and whiteboard stroke information to participants of the current meeting in full resolution. The system may have other numerous advantages.

A system and method for switching between video views and data views is described below. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the invention. It will be apparent, however, to one skilled in the art that the embodiments can be practiced without these specific details. In other instances, structures and devices are shown in block diagram form in order to avoid obscuring the invention. For example, the invention is described in one embodiment below with reference to mobile devices such as a smart phone and particular software and hardware. However, the description applies to any type of computing device that can receive data and commands, and any peripheral devices providing services.

Reference in the specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment.

Some portions of the detailed descriptions that follow are presented in terms of algorithms and symbolic representations of operations on data bits within a computer memory. These algorithmic descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers or the like.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the following discussion, it is appreciated that throughout the description, discussions utilizing terms such as "processing" or "computing" or "calculating" or "determining" or "displaying" or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

The invention also relates to an apparatus for performing the operations herein. This apparatus may be specially constructed for the required purposes, or it may comprise a general-purpose computer selectively activated or reconfigured by a computer program stored in the computer. Such a computer program may be stored in a computer readable storage medium, such as, but is not limited to, any type of disk including floppy disks, optical disks, CD-ROMs, and magnetic disks, read-only memories (ROMs), random access memories (RAMs), EPROMs, EEPROMs, magnetic or optical cards, flash memories including USB keys with non-volatile memory or any type of media suitable for storing electronic instructions, each coupled to a computer system bus.

Some embodiments can take the form of an entirely hardware embodiment, an entirely software embodiment or an embodiment containing both hardware and software elements. A preferred embodiment is implemented in software, which includes but is not limited to firmware, resident software, microcode, etc.

Furthermore, some embodiments can take the form of a computer program product accessible from a computer-usable or computer-readable medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this invention, a computer-usable or computer readable medium can be any apparatus that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

A data processing system suitable for storing and/or executing program code will include at least one processor coupled directly or indirectly to memory elements through a system bus. The memory elements can include local memory employed during actual execution of the program code, bulk storage, and cache memories which provide temporary storage of at least some program code in order to reduce the number of times code must be retrieved from bulk storage during execution. Input/output or I/O devices (including but not limited to keyboards, displays, pointing devices, etc.) can be coupled to the system either directly or through intervening I/O controllers.

Network adapters may also be coupled to the system to enable the data processing system to become coupled to other data processing systems or remote printers or storage devices through intervening private or public networks. Modems,

cable modem and Ethernet cards are just a few of the currently available types of network adapters.

Finally, the algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general-purpose systems may be used with programs in accordance with the teachings herein, or it may prove convenient to construct more specialized apparatus to perform the required method steps. The required structure for a variety of these systems will appear from the description below. In addition, the specification is not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of the various embodiments as described herein.

System Overview

FIG. **1**A illustrates a block diagram of a system **100** for switching between video views and data views according to one embodiment. The illustrated system **100** includes a hosting device **101** accessible by a host **135**, a registration server **130**, a camera **103**, display devices **107***a* . . . **107***n* and mobile devices **115***a* . . . **115***n* accessible by participants **125***a* . . . **125***n*. In FIG. **1**A and the remaining figures, a letter after a reference number, e.g., "**115***a*," represents a reference to the element having that particular reference number. A reference number in the text without a following letter, e.g., "**115**," represents a general reference to instances of the element bearing that reference number. In the illustrated embodiment, these entities of the system **100** are communicatively coupled via a network **105**.

The network **105** can be a conventional type, wired or wireless, and may have numerous different configurations including a star configuration, token ring configuration or other configurations. Furthermore, the network **105** may include a local area network (LAN), a wide area network (WAN) (e.g., the Internet), and/or other interconnected data paths across which multiple devices may communicate. In some embodiments, the network **105** may be a peer-to-peer network. The network **105** may also be coupled to or includes portions of a telecommunications network for sending data in a variety of different communication protocols. In some embodiments, the network **105** includes Bluetooth communication networks or a cellular communications network for sending and receiving data including via short messaging service (SMS), multimedia messaging service (MMS), hypertext transfer protocol (HTTP), direct data connection, WAP, email, etc. Although FIG. **1**A illustrates one network **105** coupled to the mobile devices **115**, the hosting device **101** and the registration server **130**, in practice one or more networks **105** can be connected to these entities.

A hosting environment **137** can be an environment to host a multi-user communication session. An example multi-user communication session includes a videoconferencing meeting. In some examples, a hosting environment **137** is a room where all the devices within the dashed box in FIG. **1**A are visible to users. For example, the hosting environment **137** could be a conference room environment including one or more display devices **107** and one or more cameras **103** present in the conference room. Example display devices **107** include, but are not limited to, a projector, an electronic whiteboard, a liquid-crystal display and any other conventional display devices. In one embodiment, the camera **103** is an advanced videoconferencing camera. Example cameras **103** include, but are not limited to, a high-definition (HD) video camera that captures high-resolution videos, a pan-tilt-zoom (PTZ) camera that can be mechanically controlled or a group of cameras that provide multi-view or panoramic views in the hosting environment **137**. Although two display devices **107** and one camera **103** are illustrated in FIG. **1**A, the hosting environment **137** can include one or more display devices **107** and one or more cameras **103**.

The hosting device **101**, the display devices **107***a* . . . **107***n* and the camera **103** are located within the hosting environment **137**. The hosting device **101** is communicatively coupled to the display device **107***a* via signal line **116**, the display device **107***n* via signal line **118** and the camera **103** via signal line **114**. The display device **107***a* is optionally coupled to the registration server **130** via signal line **102**; the display device **107***n* is optionally coupled to the registration server **130** via signal line **104**; and the camera **103** is optionally coupled to the registration server **130** via signal line **112**.

The hosting device **101** can be a computing device that includes a processor and a memory, and is coupled to the network **105** via signal line **131**. For example, the hosting device **101** is a hardware server. In another example, the hosting device **101** is a laptop computer or a desktop computer. The hosting device **101** is accessed by a host **135**, for example, a user that manages a meeting. The hosting device **101** includes a hosting application **109** and a storage device for storing the presentations generated by the hosting application **109**.

The hosting application **109** includes software for hosting a multi-user communication session. For example, the hosting application **109** hosts a video conferencing meeting that the host **135** manages and one or more participants **125** join using one or more mobile devices **115**. In another example, the hosting application **109** generates slides for giving a presentation.

In one embodiment, the hosting application **109** displays data to be shared with other participants **125** on one or more data screens of one or more display devices **107** in the hosting environment **137**. Data to be shared with participants **125** includes, but is not limited to, a text-based document, web page content, presentation slides, video clips, stroke-based handwritten comments and/or other user annotations, etc. The one or more data screens in the hosting environment **137** are visible to the camera **103**. For example, the presentation slides to be shared with other remote participants **125** are projected on the wall, where the projection of the presentation slides (or, at least a predetermined portion of the projection) is within a field of view of the camera **103**. In this case, the camera **103** is capable of capturing the projection of the presentation slides in one or more video frame images of a video stream.

In another example, if a user in a conference room writes comments on an electronic whiteboard, the hosting application **109** can control movement of the camera **103** so that the electronic whiteboard is visible to the camera **103**. In this case, the camera **103** is capable of capturing the comments shown in the electronic whiteboard in one or more video frame images of a video stream. The camera **103** captures a video stream including video frame images depicting the hosting environment **137**, where the video frame images contain data screens of the display devices **107** and/or the data screen of the hosting device **101**.

In one embodiment, the camera **103** sends the video stream to the hosting device **101**, causing the hosting device **101** to forward the video stream to one or more of the registration server **130** and the mobile device **115**. In another embodiment, the camera **103** sends the video stream directly to the registration server **130** and/or the mobile device **115** via the network **105**. In yet another embodiment, the camera **103** sends a latest video frame image captured by the camera **103** to the registration server **130** responsive to an occurrence of a

detection trigger event. The detection trigger event is described below in more detail with reference to FIG. **2**.

In one embodiment, the hosting application **109** or the display device **107** captures a high quality version of a data stream displayed on a data screen of the display device **107**. This high quality version of the data stream displayed on the data screen is referred to as a data stream associated with the data screen, which includes a series of data screen images (e.g., screenshot images) depicting content displayed on the data screen of the display device **107** over time. A screenshot image of a data screen depicts content displayed on the data screen at a particular moment of time. At different moments of time, different screenshot images of the data screen are captured, which form a data stream associated with the data screen. In some examples, a screenshot image of the data screen may be also referred to as a data frame of the data stream.

In some examples, the hosting application **109** captures a series of screenshot images describing a slide presentation in high resolution directly from a presentation computing device. In some additional examples, an electronic whiteboard captures original stroke information displayed on the whiteboard screen, and sends screenshot images depicting the original stroke information to the hosting application **109**.

In one embodiment, the hosting application **109** sends the data stream associated with the data screen to one or more of the mobile device **115** and the registration server **130**. In another embodiment, the display device **107** directly sends the data stream including one or more data screen images to one or more of the mobile device **115** and the registration server **130**. For example, the display device **107** periodically sends an up-to-date data screen image to the registration server **130**.

In one embodiment, the participation application **123***a* can be operable on the registration server **130**. The registration server **130** includes a processor and a memory, and is coupled to the network **105** via signal line **106**. The registration server **130** includes a database for storing registered images. The registration server **130** registers the display device **107** and receives a video feed for a meeting from the camera **103**. The video feed includes one or more video frame images. The registration server **130** runs image matching algorithms to find a correspondence between a latest video frame and a latest screenshot image of a data screen associated with the display device **107** or the hosting device **101**. If a match is found, the matching area is highlighted in the video frame image and displayed on the mobile device **115**. The registration server **130** is described below in more detail with reference to FIGS. **2** and **3**A.

In another embodiment, the participation application **123***b* may be stored on a mobile device **115***a*, which is connected to the network **105** via signal line **108**. The mobile device **115***a*, **115***n* is a computing device with limited display space that includes a memory and a processor, for example a laptop computer, a tablet computer, a mobile telephone, a smartphone, a personal digital assistant (PDA), a mobile email device or other electronic device capable of accessing a network **105**. The mobile device **115** includes a touch screen for displaying data and receiving natural gestures from a participant **125**. Examples of natural gestures include, but are not limited to, tap, double tap, long press, scroll, pan, flick, two finger tap, pinch open, pinch close, etc.

In the illustrated embodiment, the participant **125***a* interacts with the mobile device **115***a*. The mobile device **115***n* is communicatively coupled to the network **105** via signal line **110**. The participant **125***n* interacts with the mobile device **115***n*. The participant **125** can be a remote user participating in a multi-user communication session such as a videoconferencing session hosted by the hosting device **101**. The mobile devices **115***a*, **115***n* in FIG. **1**A are used by way of example. While FIG. **1**A illustrates two mobile devices **115***a* and **115***n*, the disclosure applies to a system architecture having one or more mobile devices **115**.

In one embodiment, the participation application **123** is distributed such that it may be stored in part on the mobile device **115***a*, **115***n* and in part on the registration server **130**. For example, the participation application **123***b* on the mobile device **115** acts as a thin-client application that displays the video stream or the data stream while the registration server **130** performs the screen detection steps. The participation application **123***b* on the mobile device **115***a* instructs the display to present the video stream or the data stream, for example, by rendering images in a browser. The participation application **123***b* receives user input (e.g., natural gestures) from the participant **125** and interprets the user input. For example, assume the participation application **123***b* currently displays the video stream. The participation application **123***b* receives user input from the participant **125***a* to magnify the screen so much that it overcomes a threshold and the participation application **123***b* determines that the stream should be switched to the data stream of the hosting device **101**. The participation application **123***b* sends instructions indicating to switch from the video stream to the data stream to the participation application **123***a* on the registration server **130**.

The participation application **123** can be code and routines for participating in a multi-user communication session. In one embodiment, the participation application **123** can be implemented using hardware including a field-programmable gate array (FPGA) or an application-specific integrated circuit (ASIC). In another embodiment, the participation application **123** can be implemented using a combination of hardware and software. In various embodiments, the participation application **123** may be stored in a combination of the devices and servers, or in one of the devices or servers.

FIG. **1**B is another embodiment of a system for switching between video views and data views. In this embodiment, there is no hosting device **101**. Instead, mobile devices **115** can comprise the camera **103** and the participation application **123***b*. The mobile devices **115** are coupled to the display devices **107***a*, **107***n* via signal lines **136**, **138**, respectively.

The participant **125** can activate the camera **103** on the mobile device **115** and point it at the display devices **107***a*, **107***n* to capture their content. The mobile device **115** can transmit the images directly to the registration server **130** via signal line **154**. For example, the images can serve as a query from the mobile device **115**. The participation application **123** uses the captured images to detect the screen from the video view and switches to the data view in response to receiving gestures from the participant **125**.

Example Participation Application

Referring now to FIG. **2**, an example of the participation application **123** is shown in more detail. FIG. **2** is a block diagram of a computing device **200** that includes a participation application **123**, a processor **235**, a memory **237**, an input/output device **241**, a communication unit **239** and a storage device **243** according to some examples. The components of the computing device **200** are communicatively coupled by a bus **220**. The input/output device **241** is communicatively coupled to the bus **200** via signal line **242**. In some embodiments, the computing device **200** can be one of a mobile device **115** and a registration server **130**. For example, in one embodiment, the registration server **130** can include a participation application **123** with some of the com-

ponents described below and the mobile device **115** can include some of the other components described below.

The processor **235** includes an arithmetic logic unit, a microprocessor, a general purpose controller or some other processor array to perform computations and provide electronic display signals to a display device. The processor **235** is coupled to the bus **220** for communication with the other components via signal line **222**. Processor **235** processes data signals and may include various computing architectures including a complex instruction set computer (CISC) architecture, a reduced instruction set computer (RISC) architecture, or an architecture implementing a combination of instruction sets. Although FIG. **2** includes a single processor **235**, multiple processors **235** may be included. Other processors, operating systems, sensors, displays and physical configurations are possible.

The memory **237** stores instructions and/or data that can be executed by the processor **235**. The memory **237** is coupled to the bus **220** for communication with the other components via signal line **224**. The instructions and/or data may include code for performing the techniques described herein. The memory **237** may be a dynamic random access memory (DRAM) device, a static random access memory (SRAM) device, flash memory or some other memory device. In some embodiments, the memory **237** also includes a non-volatile memory or similar permanent storage device and media including a hard disk drive, a floppy disk drive, a CD-ROM device, a DVD-ROM device, a DVD-RAM device, a DVD-RW device, a flash memory device, or some other mass storage device for storing information on a more permanent basis.

The communication unit **239** transmits and receives data to and from at least one of the hosting device **101**, the mobile device **115** and the registration server **130** depending upon where the participation application **123** is stored. The communication unit **239** is coupled to the bus **220** via signal line **226**. In some embodiments, the communication unit **239** includes a port for direct physical connection to the network **105** or to another communication channel. For example, the communication unit **239** includes a USB, SD, CAT-5 or similar port for wired communication with the mobile device **115**. In some embodiments, the communication unit **239** includes a wireless transceiver for exchanging data with the mobile device **115** or other communication channels using one or more wireless communication methods, including IEEE 802.11, IEEE 802.16, BLUETOOTH® or another suitable wireless communication method.

In some embodiments, the communication unit **239** includes a cellular communications transceiver for sending and receiving data over a cellular communications network including via short messaging service (SMS), multimedia messaging service (MMS), hypertext transfer protocol (HTTP), direct data connection, WAP, e-mail or another suitable type of electronic communication. In some embodiments, the communication unit **239** includes a wired port and a wireless transceiver. The communication unit **239** also provides other conventional connections to the network **105** for distribution of files and/or media objects using standard network protocols including TCP/IP, HTTP, HTTPS and SMTP, etc.

The storage device **243** can be a non-transitory memory that stores data for providing the functionality described herein. The storage device **243** may be a dynamic random access memory (DRAM) device, a static random access memory (SRAM) device, flash memory or some other memory devices. In some embodiments, the storage device **243** also includes a non-volatile memory or similar permanent storage device and media including a hard disk drive, a floppy disk drive, a CD-ROM device, a DVD-ROM device, a DVD-RAM device, a DVD-RW device, a flash memory device, or some other mass storage device for storing information on a more permanent basis.

In the illustrated embodiment, the storage device **243** is communicatively coupled to the bus **220** via signal line **228**. In one embodiment, the storage device **243** stores one or more of a video stream including one or more video frame images, a data stream including one or more data screen images and one or more detection trigger events, etc. The storage device **243** may store other data for providing the functionality described herein. For example, the storage device **243** could store copies of video conferencing materials, such as presentations, documents, audio clips, video clips, etc.

In the illustrated embodiment shown in FIG. **2**, the participation application **123** includes a controller **202**, a view presentation module **204**, a screen detection module **206**, a view switching module **208**, a user interface module **210** and an optional camera adjustment module **212**. The components of the participation application **123** are communicatively coupled via the bus **220**. Persons of ordinary skill in the art will recognize that the components can be stored in part on the mobile device **115** and in part on the registration server **130**. For example, the participation application **123** stored on the registration server **130** could include the screen detection module **206** and the participation application **123** stored on the mobile device could include the remaining components.

The controller **202** can be software including routines for handling communications between the participation application **123** and other components of the computing device **200**. In one embodiment, the controller **202** can be a set of instructions executable by the processor **235** to provide the functionality described below for handling communications between the participation application **123** and other components of the computing device **200**. In another embodiment, the controller **202** can be stored in the memory **237** of the computing device **200** and can be accessible and executable by the processor **235**. In either embodiment, the controller **202** can be adapted for cooperation and communication with the processor **235** and other components of the computing device **200** via signal line **230**.

In one embodiment, the controller **202** sends and receives data, via the communication unit **239**, to and from one or more of the mobile device **115**, the hosting device **101** and the registration server **130**. For example, the controller **202** receives, via the communication unit **239**, user input from a participant **125** operating on a mobile device **115** and sends the user input to the view switching module **208**. In another example, the controller **202** receives graphical data for providing a user interface to a participant **125** from the user interface module **210** and sends the graphical data to a mobile device **115**, causing the mobile device **115** to present the user interface to the participant **125**.

In one embodiment, the controller **202** receives data from other components of the participation application **123** and stores the data in the storage device **243**. For example, the controller **202** receives data describing one or more detection trigger events from the screen detection module **206** and stores the data in the storage device **243**. In another embodiment, the controller **202** retrieves data from the storage device **243** and sends the data to other components of the participation application **123**. For example, the controller **202** retrieves a data stream from the storage device **243** and sends the data stream to the view presentation module **204** for presenting the data stream to a participant **125**.

The view presentation module **204** can be software including routines for presenting a video view or a data view on a

mobile device **115**. In one embodiment, the view presentation module **204** can be a set of instructions executable by the processor **235** to provide the functionality described below for presenting a data view or a video view on a mobile device **115**. In another embodiment, the view presentation module **204** can be stored in the memory **237** of the computing device **200** and can be accessible and executable by the processor **235**. In either embodiment, the view presentation module **204** can be adapted for cooperation and communication with the processor **235** and other components of the computing device **200** via signal line **232**.

A video view mode presents video data associated with a multi-user communication session to a participant **125**. For example, the video view mode presents the video stream of the other participants in the multi-user communication session to the participant **125** in full screen on the mobile device **115**. In another example, the video view mode presents the video stream on the mobile device **115** in full resolution.

In one embodiment, the view presentation module **204** receives data indicating that a participant **125** joins a multi-user communication session from a mobile device **115** associated with the participant **125**. Correspondingly, the mobile device **115** is in the video view mode. The view presentation module **204** receives a video stream including one or more video frame images from the camera **103** directly or via the hosting device **101**, and presents the video stream to the participant **125** on a display of the mobile device **115**.

In some examples, one or more data screens that are in the same hosting environment **137** as the camera **103** are captured in the one or more video frame images of the video stream, and the one or more video frame images include sub-images depicting the one or more data screens. For example, the one or more video frame images capture at least a portion of a data screen of a hosting device **101**, a portion of a screen projection on the wall and/or a portion of a data screen of an electronic whiteboard. In another example, the one or more video frame images capture the full data screen of the hosting device **101**, the full projection screen on the wall and/or the full data screen of the electronic whiteboard.

A data view mode presents a data stream associated with the multi-user communication session to the participant **125**. For example, the data view mode presents a data stream with the slides being presented during the multi-user communication session to the participant **125** in full screen on the mobile device **115**. In another example, the data view mode presents the data stream on the mobile device **115** in full resolution.

In one embodiment, the view presentation module **204** receives, from the view switching module **208**, an identifier (ID) of a detected data screen and a view switching signal indicating that a view on the mobile device **115** should be switched from the video view to the data view. In some embodiments, the view presentation module **204** receives a data stream associated with the detected data screen directly from the display device **107** associated with the data screen. In some other embodiments, the view presentation module **204** receives the data stream via the hosting device **101**. Responsive to receiving the view switching signal, the view presentation module **204** stops presenting the video stream on the mobile device **115** and starts to present the data stream associated with the data screen on the mobile device **115**. Persons of ordinary skill in the art will recognize that the sections describing presenting the video stream or data stream are meant to represent the view presentation module **204** instructing the user interface module **210** to generate graphical data that is sent to the mobile device **115** via the communication unit **239** for display.

In some examples, an embedded data stream is included in the data stream. The view presentation module **204** receives, from the view switching module **208**, a view switching signal instructing the view presentation module **204** to switch the view on the mobile device **115** from the data view to an embedded data view. The embedded data view mode presents the embedded data stream to the participant **125** in full resolution or in full screen on the mobile device **115**. Responsive to receiving the view switching signal, the view presentation module **204** stops presenting the data stream and starts to present the embedded data stream on the mobile device **115**. An embedded data stream can be a videoconferencing meeting, a presentation, a video clip, a text document, presentation slides, or other types of data embedded in the data stream.

If the view presentation module **204** receives a view switching signal instructing the view presentation module **204** to switch the view from the embedded data view back to the data view from the view switching module **208**, the view presentation module **204** stops presenting the embedded data stream and starts to present the data stream on the mobile device **115** again. In one embodiment, the view presentation module **204** receives a view switching signal instructing the view presentation module **204** to switch the view on the mobile device **115** from the data view to the video view from the view switching module **208**. Responsive to the view switching signal, the view presentation module **204** stops presenting the data stream and starts to present the video stream on the mobile device **115**.

The screen detection module **206** can be software including routines for performing data screen detection in a video frame image. In one embodiment, the screen detection module **206** can be a set of instructions executable by the processor **235** to provide the functionality described below for performing data screen detection in a video frame image. In another embodiment, the screen detection module **206** can be stored in the memory **237** of the computing device **200** and can be accessible and executable by the processor **235**. In either embodiment, the screen detection module **206** can be adapted for cooperation and communication with the processor **235** and other components of the computing device **200** via signal line **234**.

In one embodiment, the screen detection module **206** registers one or more display devices **107** with the registration server **130**. For example, the screen detection module **206** can record a device identifier, a user associated with the display device **107**, etc. with the display device **107** and store the registration information in the storage **243**. Each display device **107** sends an updated image of its data screen to the registration server **130** periodically. For example, each display device **107** sends its up-to-date screenshot image to the registration server **130** periodically. In some examples, the display device **107** sends the updated screenshot images of its data screen to the registration server **130** via the hosting device **101**.

In one embodiment, the screen detection module **206** detects an occurrence of a trigger event. For example, the event could be a detection trigger event that triggers a detection of one or more data screens in a video frame image. For example, a detection trigger event causes the screen detection module **206** to detect whether the video frame image includes a data screen. Example detection trigger events include, but are not limited to, motion of the camera **103** (e.g., panning, zooming or tilting of the camera **103**, movement of the camera **103**, etc.) and/or motion of an object in the video frame image (e.g., appearance of a projection on the wall in the video frame image, movement of a whiteboard, etc.). In another example, the trigger event could be based on a timer.

Responsive to the occurrence of the detection trigger event, the screen detection module **206** receives a latest video frame image of the video stream from the camera **103** directly or via the hosting device **101**. In some examples, the screen detection module **206** receives the latest video frame image of the video stream from the mobile device **115** or a video server that provides the video stream. The screen detection module **206** performs data screen detection in the latest video frame image responsive to the occurrence of the detection trigger event. For example, the screen detection module **206** determines whether a data screen appears in the latest video frame image by matching a latest screenshot image of the data screen with the latest video frame image.

In some examples, for each data screen registered with the registration server **130**, the screen detection module **206** determines whether a sub-image that matches the latest screenshot image of the data screen appears in the latest video frame image. For example, the screen detection module **206** determines whether the latest video frame image includes a sub-image that depicts the data screen (e.g., the screen detection module **206** determines whether the data screen is captured by the latest video frame image). In a further example, the screen detection module **206** runs an image matching algorithm to find the correspondence between the latest video frame image and the latest screenshot image of the data screen. If the screen detection module **206** finds a match between the latest video frame image and the latest screenshot image of the data screen, the screen detection module **206** highlights the matching area in the video frame image on the mobile device **115**. For example, the screen detection module **206** highlights the detected data screen in the video frame image on the mobile device **115**.

In one embodiment, the screen detection module **206** runs the image matching algorithm in real time. An example image matching algorithm includes a scale-invariant feature transform (SIFT) algorithm. The SIFT algorithm extracts feature points of both the latest video frame image and the latest screenshot image of the data screen, where the feature points from both images are matched based on the k-nearest neighbors (KNN), and the random sample consensus (RANSAC) algorithm is used to find the consensus and to determine the homographic matrix. Additional information about how to use SIFT, KNN and RANSAC for image matching can be found at Hess, R., *An Open-Source SIFT Library*, Proceedings of the International Conference on Multimedia, October 2010, pp. 1493-96. Persons of ordinary skill in the art will recognize that other image matching algorithms can be used.

If the screen detection module **206** detects one or more data screens existing in the video frame image, the screen detection module **206** generates a matching result including one or more matches between the one or more data screens and the video frame image. The screen detection module **206** notifies the mobile device **115** of the one or more matches, and establishes a direct connection between the mobile device **115** and each display device **107** that has one matched data screen. The screen detection module **206** highlights one or more matching areas in the video frame image, where each matching area corresponds to a position of one data screen captured in the video frame image. The screen detection module **206** displays the highlighted matching areas on the mobile device **115**.

In another embodiment, the camera **103** is statically deployed and captures one or more data screens in the hosting environment **137**, and positions of the one or more data screens remain unchanged in the video frame images. The screen detection module **206** can determine existence of the one or more data screens based on the static setting in the hosting environment **137**, and can pre-calibrate positions of the one or more data screens in the video frame images. The screen detection module **206** highlights the one or more data screens in the video frame images at the pre-calibrated positions in the video frame images.

The screen detection module **206** sends one or more screen IDs identifying the one or more detected data screens and data describing one or more matching areas in the video frame image to the view switching module **208**. In another embodiment, the screen detection module **206** sends pre-calibrated positions of one or more data screens to the view switching module **208**. In yet another embodiment, the screen detection module **206** stores the one or more screen IDs, data describing the one or more matching areas and/or the pre-calibrated positions in the storage **243**.

The view switching module **208** can be software including routines for switching a view on a mobile device **115** between a video view and a data view. In one embodiment, the view switching module **208** can be a set of instructions executable by the processor **235** to provide the functionality described below for switching a view on a mobile device **115** between a video view and a data view. In another embodiment, the view switching module **208** can be stored in the memory **237** of the computing device **200** and can be accessible and executable by the processor **235**. In either embodiment, the view switching module **208** can be adapted for cooperation and communication with the processor **235** and other components of the computing device **200** via signal line **236**.

In one embodiment, the view switching module **208** receives, from the screen detection module **206**, data describing one or more screen IDs identifying one or more detected data screens and one or more matching areas associated with the one or more detected data screens in the video frame image. In the video view mode, the mobile device **115** presents the video stream to the participant **125**, with the one or more detected data screens highlighted in the matching areas of the video frame images. If the participant **125** performs a natural gesture (e.g., a pinch open or double tap gesture, etc.) within a highlighted matching area of a data screen on a touch screen of the mobile device **115**, the view switching module **208** interprets the participant's natural gesture as a command to switch from the video view to the data view. The view switching module **208** generates a view switching signal describing the command and sends the view switching signal to the view presentation module **204**, causing the view presentation module **204** to present the data view to the participant **125**. In one embodiment, the view switching module **208** interprets the natural gesture as a command to switch from the video view to the data view if the portion of the data screen detected in the video frame image is greater than a predetermined threshold (e.g., a majority portion of the data screen appearing in the video frame image).

For example, the participant **125** can use a natural gesture to zoom into a data screen detected in the video frame image, so that the video view presenting the video frame image scales up accordingly on the touch screen of the mobile device **115**. If the size of the scaled-up data screen in the video frame image reaches a predetermined threshold, the view switching module **208** automatically switches the view on the mobile device **115** from the video view to the data view, causing the view presentation module **204** to present the data stream associated with the detected data screen on the mobile device **115**. The mobile device **115** switches from the video view mode to the data view mode accordingly. The participant **125** can further perform natural gestures to operate on the data stream such as zooming into the data stream, copying the data stream, dragging the data stream, etc.

In the data view mode, the mobile device **115** presents the data stream to the participant **125**. If the participant **125** performs a natural gesture (e.g., a pinch close gesture or tapping on an exit icon, etc.) on the data stream displayed on a touch screen of the mobile device **115**, the view switching module **208** interprets the participant's natural gesture as a command to switch from the data view back to the video view. The view switching module **208** generates a view switching signal describing the command and sends the view switching signal to the view presentation module **204**, causing the view presentation module **204** to present the video view to the participant **125**. Again, the screen detection module **206** detects the one or more data screens visible to the camera **103** in the video frame images, and highlights the one or more data screens in the video frame images. For example, the participant **125** can use a natural gesture to zoom out the data stream, so that the data view presenting the data stream scales down accordingly on the touch screen of the mobile device **115**. If the size of the scaled down data stream reaches a predetermined threshold, the view switching module **208** automatically switches the view on the mobile device **115** from the data view to the video view, causing the view presentation module **204** to present the video stream on the mobile device **115**.

In the data view mode, if the presented data stream includes an embedded data stream, the participant **125** can use a natural gesture on the embedded data stream. The view switching module **208** interprets the natural gesture as a command to switch from the data view to the embedded data view. The view switching module **208** generates a view switching signal describing the command and sends the view switching signal to the view presentation module **204**, causing the view presentation module **204** to present the embedded data stream to the participant **125** in full resolution. The participant **125** may perform another natural gesture to exit from the embedded data view and return to the data view. For example, if the data stream includes an embedded video, the participant **125** can issue a tap open command on an icon representing the embedded video during the data view mode, causing the view presentation module **204** to present the embedded video in full screen on the mobile device **115**. After viewing the embedded video, the participant **125** can issue a pinch close command to exit from the embedded data view and return to the data view.

The user interface module **210** can be software including routines for generating graphical data for providing a user interface. In one embodiment, the user interface module **210** can be a set of instructions executable by the processor **235** to provide the functionality described below for generating graphical data for providing a user interface. In another embodiment, the user interface module **210** can be stored in the memory **237** of the computing device **200** and can be accessible and executable by the processor **235**. In either embodiment, the user interface module **210** can be adapted for cooperation and communication with the processor **235** and other components of the computing device **200** via signal line **238**.

In one embodiment, the user interface module **210** receives instructions from the view presentation module **204** to generate graphical data for providing a user interface to a user such as a host **135** or a participant **125**. The user interface module **210** sends the graphical data to the hosting device **101** or the mobile device **115**, causing the hosting device **101** or the mobile device **115** to present the user interface to the user. For example, the user interface module **210** generates graphical data for providing a user interface that depicts a video stream or a data stream. The user interface module **210** sends the graphical data to the mobile device **115**, causing the mobile device **115** to present the video stream or the data stream to the participant **125** via the user interface. In other embodiments, the user interface module **210** may generate graphical data for providing other user interfaces to users.

The optional camera adjustment module **212** can be software including routines for adjusting a camera **103**. In one embodiment, the camera adjustment module **212** can be a set of instructions executable by the processor **235** to provide the functionality described below for adjusting a camera **103**. In another embodiment, the camera adjustment module **212** can be stored in the memory **237** of the computing device **200** and can be accessible and executable by the processor **235**. In either embodiment, the camera adjustment module **212** can be adapted for cooperation and communication with the processor **235** and other components of the computing device **200** via signal line **240**.

In one embodiment, a participant **125** can use natural gestures to navigate the camera **103**. For example, the participant **125** can perform a natural gesture to change the view angle of the camera **103** via a user interface shown on the mobile device **115**. The camera adjustment module **212** receives data describing the participant's natural gesture and interprets the participant's natural gesture as a command to adjust the camera **103** such as panning, tilting, zooming in or zooming out the camera **103**. The camera adjustment module **212** adjusts the camera **103** according to the participant's natural gesture. Through adjusting the camera **103**, the participant **125** may keep one or more data screens of one or more display devices **107** within the field of view of the camera **103**, so that the camera **103** captures the one or more data screens in the video frame images.

An example use of the system described herein includes a videoconferencing scenario, where a first party (e.g., a host **135**) is in a conference room equipped with a camera **103** and one or more data screens, and a second party (e.g., a participant **125**) is a remote mobile user participating the videoconference using a mobile device **115** such as a smart phone or a tablet. After the participant **125** joins the videoconference, the participation application **123** receives a video stream from the camera **103** and presents the video stream to the participant **125** on a touch screen of the mobile device **115**. The participation application **123** detects one or more data screens captured by video frame images. The participant **125** can issue a natural gesture such as a pinch open gesture on a detected data screen highlighted in the video frame images, causing the mobile device **115** to switch from video view to data view. Afterwards, the participation application **123** presents a data stream associated with the detected data screen to the participant **125** in full resolution. The participant **125** may issue another natural gesture such as a pinch close gesture to switch from the data view back to the video view.

Another example use of the system described herein includes a retrieval application for retrieving information relevant to an image. For example, a user can capture an image of an advertisement (e.g., an advertisement for a vehicle brand), and instruct the retrieval application to retrieve information relevant to the advertisement. The image of the advertisement may include a banner and/or a data screen image showing a commercial video. The retrieval application can instruct the screen detection module **206** to detect the data screen in the image of the advertisement and to identify a product that matches content shown in the data screen image. The retrieval application may retrieve information relevant to the identified product from one or more databases and provide the relevant information to a user. Other example uses of the system described herein are possible.

Graphic Representations

FIG. **3**A is a graphic representation **300** illustrating one embodiment of a process for performing data screen detection. After a participant **125** joins a multi-user communication session using the mobile device **115**, the camera **103** establishes a video stream connection **302** with the mobile device **115**. The camera **103** sends a video stream to the mobile device **115** via the video stream connection **302**, causing the mobile device **115** to present the video stream to the participant **125** in a video view mode. The display device **107** registers with the registration server **130** and sends updated screenshot images **304** of a data screen associated with the display device **107** to the registration server **130** periodically. In the illustrated example, the display device **107** is an electronic whiteboard. In one embodiment, the registration server **130** detects a detection trigger event. For example, the registration server **130** detects motion of the camera **103** such as panning or tilting. The registration server **130** receives a latest video frame image **306** from the camera **103** responsive to the detection trigger event. In some examples, the registration server **130** receives the latest video frame image **306** from the mobile device **115**.

The registration server **130** uses an image-matching method to detect active data screens dynamically. For example, the registration server **130** uses an image matching algorithm to find the correspondence between the latest video frame image **306** and the latest screenshot image received from either the hosting device **101** or the display device **107**. If a matching result **308** between the latest video frame image **306** and the latest screenshot image of the data screen is found, the registration server **130** notifies the mobile device **115** of the matching result **308** and highlights the corresponding data screen in the video frame images. For example, the registration server **130** uses a box **310** to highlight a data screen of an electronic whiteboard in the video frame image. The display device **107** associated with the data screen establishes a data stream connection **312** with the mobile device **115**. The display device **107** may send a data stream to the mobile device **115** via the data stream connection **312**.

FIG. **3**B is a graphic representation **319** illustrating one embodiment for switching between video views and data views on a mobile device **115** using natural gestures. The participation application **123** interprets natural gestures from a participant **125** to achieve the seamless user experience. In this embodiment, the participation application **123** captures and transmits a first data stream and a second data stream along with the video stream captured from the camera **103** to the mobile device **115**. The first data stream includes the high quality screenshot images from the hosting device **101** (e.g., a laptop), and the second data stream includes the strokes from the display device **107** (e.g., an electronic whiteboard). Both data screens (the data screen of the laptop and the data screen of the electronic whiteboard) are visible to the camera **103**. In one embodiment, the screenshot images from the hosting device **101** include an embedded image depicting the data screen of the display device **107**.

At the beginning, the video view is shown on the mobile device **115** to present the video frame image **320** to the participant **125**. For example, the video frame image **320** is shown in full resolution or on full screen of the mobile device **115**. As shown in FIG. **3**B, both data screens (the data screen **324** of the laptop and the data screen **322** of the electronic whiteboard) are visible in the video frame image **320** displayed on the participant's mobile device **115**. The participation application **123** intelligently detects and notifies the participant **125** of the existence of data screens in the video frame images. For example, the participation application **123** highlights the data screens **322** and **324** in the video frame image **320**.

At phase (1), if the participant **125** tries to get more detail from the laptop data screen **324**, he or she can perform a natural gesture **330** on the laptop data screen **324** shown in the video frame image **320** to zoom into the laptop data screen **324**. An example natural gesture **330** can be a pinch or double tap gesture. Responsive to the natural gesture **330**, the video view on the mobile device **115** scales up. If the size of the recognized laptop data screen **324** reaches a pre-set threshold, the mobile device **115** automatically switches from the video view to the data view. For example, the view on the mobile device **115** switches from presenting the video frame image **320** in full resolution to presenting a high quality screenshot image **326** of the laptop data screen **324** in full resolution. The participation application **123** interprets any further pinch or dragging gestures performed on the screenshot image **326** as operating on the screenshot image **326** of the laptop data screen **324**.

At phase (2), when the participant **125** performs a natural gesture **332** such as a pinch gesture on the screenshot image **326** to zoom out of the data view and the zoom-out scale ratio reaches a pre-set threshold, the mobile device **115** switches back to the video view from the data view. Again, the participation application **123** presents the video frame image **320** on the mobile device **115** in full resolution, and detects and marks the visible data screens **322** and **324** in the video frame image **320**.

At phase (3), the participant **125** performs a natural gesture **334** such as a dragging gesture on the highlighted data screen **322** in the video frame image **320**, causing the mobile device **115** to enlarge the video view greater than a threshold amount, which causes the mobile device **115** to switch from showing the video frame image **320** in full resolution to the data view showing a screenshot image **328** of the electronic whiteboard in full resolution. At phase (4), the participant **125** performs a natural gesture **336** such as a pinch gesture on the screenshot image **328** to zoom out the data view, causing the mobile device **115** to decrease the data view until a threshold point triggers the mobile device **115** to switch back to the video view from the data view. Again, the mobile device **115** presents the video frame image **320** to the participant **125**.

FIG. **4**A is a graphic representation **400** of one embodiment of a graphic user interface illustrating a video view on a mobile device **115**. The example user interface shows a video frame image **402** depicting a conference room. The video frame image **402** depicts a host **135** and a data screen **404** of the hosting device **101** projected on a wall of the conference room. The data screen **404** includes an embedded data screen **406**. If the participant **125** performs a natural gesture on the data screen **404** captured in the video frame image **402**, the mobile device **115** switches from the video view to the data view shown in FIG. **4**B.

FIG. **4**B is a graphic representation **420** of one embodiment of a graphic user interface illustrating a data view on a mobile device **115**. In this example, a data stream including screenshot images of the data screen **404** is presented on the mobile device **115**. The data stream is a multi-user communication session including an embedded data stream. For example, the data stream is a video clip of another conference with embedded slides. The embedded data screen **406** presenting the embedded slides is shown in the screenshot image of the data screen **404**.

When the participant **125** switches to the data view shown in FIG. **4**B from the video view shown in FIG. **4**A, the data stream including the video clip starts to play. In one embodi-

ment, the participant **125** may exit from the data view shown in FIG. **4**B and return to the video view shown in FIG. **4**A by performing a natural gesture (e.g., a pinch to close gesture) on the screenshot image of the data screen **404**. In one embodiment, the participant **125** can keep zooming into the data view if the video clip includes embedded presentation slides or whiteboard strokes information. For example, if the participant **125** performs a natural gesture on the embedded data screen **406**, the mobile device **115** can switch from the data view to an embedded data view shown in FIG. **4**C to present slides embedded in the video clip.

FIG. **4**C is a graphic representation **440** of one embodiment of a graphic user interface illustrating an embedded data view on a mobile device **115**. In this example, the slides shown in the embedded data screen **406** is presented to the participant **125**. The participant **125** may exit from the embedded data view and return to the data view shown in FIG. **4**B by performing a natural gesture (e.g., a pinch to close gesture) on the screenshot image of the embedded data screen **406**.

Methods

FIG. **5** is a flow diagram illustrating one embodiment of a method **500** for switching between video views and data views using natural gestures in a multi-user communication session. In one embodiment, the controller **202** receives **502** data indicating that a participant **125** joined a multi-user communication session from a mobile device **115** associated with the participant **125**. The view presentation module **204** presents **504** a video stream of the multi-user communication session to the mobile device **115**. For example, the view presentation module **204** instructs the user interface engine **210** to generate graphical data for displaying the video stream. In one embodiment, the screen detection module **206** determines an occurrence of a detection trigger event. The controller **202** receives **506** a video frame image from the video stream responsive to the occurrence of the detection trigger event. For example, the controller **202** receives a latest video frame image of the video stream from the camera **103**. The screen detection module **206** detects **508** a first data screen in the video frame image. For example, the screen detection module **206** determines that the video frame image captures the first data screen.

The controller **202** receives **510** data describing a first natural gesture performed on the mobile device **115**. For example, the controller **202** receives data describing a pinch to open gesture performed on the first data screen in the video frame image. The view switching module **208** switches **512** a view on the mobile device **115** from video view to data view responsive to the first natural gesture. The view presentation module **204** presents **514** a first data stream associated with the first data screen on the mobile device **115**. In one embodiment, the first data stream includes one or more high-definition screenshot images of the first data screen generated by a display device **107** associated with the first data screen.

FIGS. **6**A-**6**C are flow diagrams illustrating another embodiment of a method **600** for switching between video views and data views using natural gestures in a multi-user communication session. Referring to FIG. **6**A, the controller **202** receives **602** data indicating that a participant **125** joined a multi-user communication session from a mobile device **115** associated with the participant **125**. The view presentation module **204** presents **604** a video stream of the multi-user communication session on the mobile device **115**. The screen detection module **206** registers **606** a display device **107** with the registration server **130**. The display device **107** includes a data screen for presenting a data stream of the multi-user communication session in the hosting environment **137**. The controller **202** receives **608** images of the data screen from the display device **107** periodically. For example, the controller **202** receives screenshot images of the data screen from the display device **107** periodically.

The screen detection module **206** detects **610** an occurrence of a detection trigger event. The controller **202** receives **612** a latest video frame image from the camera **103** responsive to the occurrence of the detection trigger event. The screen detection module **206** performs **614** data screen detection in the latest video frame image using the latest image of the data screen received from the display device **107**.

Referring to FIG. **6**B, the screen detection module **206** determines **616** whether a sub-image that matches the latest image of the data screen is found in the latest video frame image. If the sub-image is found in the latest video frame image, the method **600** moves to step **618**. Otherwise, the method **600** ends. Turning to step **618**, the screen detection module **206** generates a matching result indicating the match between the latest image of the data screen and the latest video frame image, and notifies the mobile device **115** of the matching result. The screen detection module **206** provides data between the mobile device **115** and the display device **107** associated with the data screen. For example, the screen detection module **206** establishes a direct connection between the devices. In one embodiment, the display device **107** can transmit a data stream associated with the data screen to the mobile device **115** via the direct connection.

The controller **202** receives **622** data describing a first natural gesture performed by the participant **125** on the sub-image depicting the data screen in the video frame image. The controller **202** receives **624** a data stream associated with the data screen from the display device **107**. The view switching module **208** switches **626** a view on the mobile device **115** from video view to data view responsive to the first natural gesture exceeding a threshold. For example, the user makes an expanding view starting in the center of the screen and moving over half the width of the screen. The view presentation module **204** presents **628** the data stream associated with the data screen on the mobile device **115**.

Referring to FIG. **6**C, the controller **202** receives **630** data describing a second natural gesture performed by the participant **125** on the data stream. The view switching module **208** switches **632** the view on the mobile device **115** from data view back to video view responsive to the second natural gesture exceeding a threshold. The view presentation module **204** presents **634** the video stream on the mobile device **115**.

FIG. **7** is a flow diagram illustrating one embodiment of a method **700** for switching between a video view and one of two different data views using a selection in a multi-user communication session. In one embodiment, the controller **202** receives **702** data indicating that a first participant, a second participant and a third participant **125** joined a multi-user communication session. The view presentation module **204** presents **704** a video stream of the multi-user communication session to a mobile device **115** associated with the third participant **125**. For example, the view presentation module **204** instructs the user interface engine **210** to generate graphical data for displaying the video stream. In one embodiment, the screen detection module **206** determines an occurrence of a detection trigger event. The controller **202** receives **706** a video frame image from the video stream that includes a first device associated with the first participant and a second device associated with the second participant. For example, the controller **202** receives a latest video frame image of the video stream from the camera **103**. The screen detection module **206** detects **708** a first data screen from the first device and a second data screen from the second device in the video frame image.

The controller **202** receives **710** data describing a selection of the first data screen performed on the mobile device **115**. For example, the controller **202** receives data describing a finger pressing in the center of the image of the first device to indicate that the third participant wants to view the first data view. The view switching module **208** switches **712** a view on the mobile device **115** from video view to a first data view that corresponds to the first data screen responsive to the selection. The view presentation module **204** presents **714** the first data stream on the mobile device **115**.

The foregoing description of the embodiments has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the specification to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the embodiments be limited not by this detailed description, but rather by the claims of this application. As will be understood by those familiar with the art, the examples may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Likewise, the particular naming and division of the modules, routines, features, attributes, methodologies and other aspects are not mandatory or significant, and the mechanisms that implement the description or its features may have different names, divisions and/or formats. Furthermore, as will be apparent to one of ordinary skill in the relevant art, the modules, routines, features, attributes, methodologies and other aspects of the specification can be implemented as software, hardware, firmware or any combination of the three. Also, wherever a component, an example of which is a module, of the specification is implemented as software, the component can be implemented as a standalone program, as part of a larger program, as a plurality of separate programs, as a statically or dynamically linked library, as a kernel loadable module, as a device driver, and/or in every and any other way known now or in the future to those of ordinary skill in the art of computer programming. Additionally, the specification is in no way limited to embodiments in any specific programming language, or for any specific operating system or environment. Accordingly, the disclosure is intended to be illustrative, but not limiting, of the scope of the specification, which is set forth in the following claims.

What is claimed is:

1. A computer-implemented method comprising:

receiving, with one or more processors, data indicating a participant joined a multi-user communication session;

presenting, with the one or more processors, a video stream of the multi-user communication session on a mobile device associated with the participant;

receiving, with the one or more processors, a video frame image from the video stream responsive to an occurrence of a detection trigger event;

receiving, with the one or more processors, a first image of a first data screen from a first display device;

detecting, with the one or more processors, a second image within the video frame image that matches the first image of the first data screen, the second image being another image of the first data screen captured in the video frame image;

receiving, with the one or more processors, data describing a first natural gesture performed on the mobile device;

switching, with the one or more processors, a view on the mobile device from video view to data view responsive to the first natural gesture exceeding a threshold; and

presenting, with the one or more processors, a first data stream associated with the first data screen on the mobile device.

2. The method of claim **1**, further comprising:

notifying the mobile device of a match between the first image of the first data screen and the second image within the video frame image; and

providing data between the mobile device and the first display device.

3. The method of claim **1**, wherein the detection trigger event includes one of motion of a camera and motion of an object captured in the video frame image.

4. The method of claim **1**, further comprising:

receiving data describing a second natural gesture performed on the mobile device;

switching the view on the mobile device from data view to video view responsive to the second natural gesture exceeding a threshold; and

presenting the video stream on the mobile device.

5. The method of claim **4**, further comprising:

detecting a second data screen in the video frame image;

receiving data describing a third natural gesture performed on the mobile device;

switching the view on the mobile device from video view to data view responsive to the third natural gesture exceeding a threshold; and

presenting a second data stream associated with the second data screen on the mobile device.

6. The method of claim **1**, wherein the first data stream includes content presented on the first data screen.

7. The method of claim **1**, wherein the first data stream includes an embedded data stream, and the method further comprising:

receiving data describing a fourth natural gesture performed on the mobile device; and

presenting the embedded data stream on the mobile device responsive to the fourth natural gesture.

8. A system comprising:

one or more processors;

a controller stored on a memory and executable by the one or more processors, the controller configured to receive data indicating a participant joined a multi-user communication session the controller configured to receive data describing a first natural gesture performed on a mobile device associated with the participant;

a view presentation module stored on the memory and executable by the one or more processors, the view presentation module configured to present a video stream of the multi-user communication session on the mobile device responsive to the participant joining the multi-user communication session, the view presentation module configured to present a first data stream associated with a first data screen on the mobile device responsive to the first natural gesture;

a screen detection module stored on the memory and executable by the one or more processors, the screen detection module configured to determine an occurrence of a detection trigger event, the screen detection module configured to receive a first image of the first data screen from the first display device and detect a second image within the video frame image that matches the first image of the first data screen, the second image being another image of the first data screen captured in the video frame image; and

a view switching module stored on the memory and executable by the one or more processors, the view switching module configured to switch a view on the mobile device from video view to data view responsive to the first natural gesture exceeding a threshold.

9. The system of claim 8, wherein the screen detection module is configured to:

notify the mobile device of a match between the first image of the first data screen and the second image within the video frame image; and

provide data between the mobile device and the first display device.

10. The system of claim 8, wherein the detection trigger event includes one of motion of a camera and motion of an object captured in the video frame image.

11. The system of claim 8, wherein:

the controller is further configured to receive data describing a second natural gesture performed on the mobile device;

the view switching module is further configured to switch the view on the mobile device from data view to video view responsive to the second natural gesture exceeding a threshold; and

the view presentation module is further configured to present the video stream on the mobile device.

12. The system of claim 8, wherein:

the screen detection module is further configured to detect a second data screen in the video frame image;

the controller is further configured to receive data describing a third natural gesture performed on the mobile device;

the view switching module is further configured to switch the view on the mobile device from video view to data view responsive to the third natural gesture exceeding a threshold; and

the view presentation module is further configured to present a second data stream associated with the second data screen on the mobile device.

13. The system of claim 8, wherein the first data stream includes content presented on the first data screen.

14. The system of claim 8, wherein:

the first data stream includes an embedded data stream;

the controller is further configured to receive data describing a fourth natural gesture performed on the mobile device; and

the view presentation module is further configured to present the embedded data stream on the mobile device responsive to the fourth natural gesture.

15. A computer-implemented method comprising:

receiving, with one or more processors, data indicating that a first participant, a second participant and a third participant joined a multi-user communication session;

presenting, with the one or more processors, a video stream of a multi-user communication session to a mobile device associated with the third participant;

receiving, with the one or more processors, a video frame image from the first video stream that includes a first device associated with the first participant and a second device associated with the second participant;

receiving, with the one or more processors, a first image of a first data screen from the first device and a second image of a second data screen from the second device;

detecting a third image within the video frame image that matches the first image of the first data screen, the third image being another image of the first data screen captured in the video frame image;

detecting a fourth image within the video frame image that matches the second image of the second data screen, the fourth image being another image of the second data screen captured in the video frame image;

receiving, with the one or more processors, data describing a selection of the first data screen from at least two options including the first data screen and the second data screen, the selection performed on the mobile device;

switching, with the one or more processors, a view on the mobile device from video view to a first data view that corresponds to the first data screen responsive to the selection of the first data screen; and

presenting, with the one or more processors, a first data stream associated with the first data screen on the mobile device.

16. The method of claim 15, further comprising:

notifying the mobile device of a match between the first image of the first data screen and the third image within the video frame image; and

providing data between the mobile device and the first device.

17. The method of claim 15, wherein presenting the video stream is responsive to a detection trigger event that includes one of motion of a camera and motion of an object captured in the video frame image.

18. The method of claim 15, further comprising:

receiving data describing a natural gesture performed on the mobile device;

switching the view on the mobile device from data view to video view responsive to the natural gesture exceeding a threshold; and

presenting the video stream on the mobile device.

19. The method of claim 18, further comprising:

receiving data describing a selection of the second data screen performed on the mobile device;

switching the view on the mobile device from video view to a second data view that corresponds to the second data screen responsive to the selection of the second data screen; and

presenting a second data stream associated with the second data screen on the mobile device.

20. The method of claim 15, wherein the first data stream includes content presented on the first data screen.

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